Issued March 5, 1918.

HAWAII AGRICULTURAL EXPERIMENT STATION,
J. M. WESTGATE, Agronomist in Charge.

# REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION.

# 1917.

UNDER THE SUPERVISION OF
STATES RELATIONS SERVICE,
Office of Experiment Stations,
U. S. DEPARTMENT OF AGRICULTURE.

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## HAWAII AGRICULTURAL EXPERIMENT STATION, HONOLULU.

[Under the supervision of A. C. TRUE, Director of the States Relations Service, United States Department of Agriculture.]

E. W. ALLEN, *Chief of Office of Experiment Stations.*

WALTER H. EVANS, *Chief of Division of Insular Stations, Office of Experiment Stations.*

STATION STAFF.

J. M. WESTGATE, *Agronomist in Charge.*
J. EDGAR HIGGINS, *Horticulturist.*
M. O. JOHNSON, *Chemist.*
F. G. KRAUSS, *Superintendent of Extension Work.*
C. W. CARPENTER, *Plant Pathologist.*
J. B. THOMPSON,[1] *Assistant Agronomist, in Charge of Glenwood Substation.*
ALICE R. THOMPSON,[1] *Assistant Chemist.*
C. A. SAHR, *Assistant Agronomist.*
A. T. LONGLEY,[1] *In Charge of Cooperative Marketing Investigations.*
J. W. LOVE, *Executive Clerk.*

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# LETTER OF TRANSMITTAL.

HAWAII AGRICULTURAL EXPERIMENT STATION,
*Honolulu, Hawaii, July 17, 1917.*

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Hawaii Agricultural Experiment Station, 1917.

Respectfully,

J. M. WESTGATE,
*Agronomist in Charge.*

Dr. A. C. TRUE,
*Director States Relations Service,*
*U. S. Department of Agriculture, Washington, D. C.*

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
D. F. HOUSTON,
*Secretary of Agriculture.*

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[1] On leave.

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# REPORT OF THE HAWAII AGRICULTURAL EXPERIMENT STATION, 1917.

## SUMMARY OF INVESTIGATIONS.

By J. M. Westgate, *Agronomist in Charge.*

### INTRODUCTION.

The present world food shortage has emphasized more clearly than ever before the isolated position of the Hawaiian Islands and their dependence on outside sources for their food supply. The focusing of attention on the vital necessity for the local production of a much greater proportion of the food consumed on the islands has led to a gratifying response on the part of numerous organizations and individuals. It is fully realized that in making serious efforts to become self-supporting, Hawaii is doing a real service both to herself and to the country at large, as every pound of food produced here releases just that much for use elsewhere, besides providing the best form of insurance against the possible consequences of complete isolation from the mainland.

As far as practicable the resources and activities of the station have been brought to bear directly on the local production of foods and forage crops. In all this work, there has been the most cordial cooperation on the part of the various individuals, organizations, and institutions concerned. In competing with the agricultural districts of the mainland, certain vital difficulties are encountered on the islands, and means of overcoming these are being sought. The hilly, often rocky, land available for the production of food crops usually requiring much hand labor in its cultivation, the isolated nature of most of the agricultural districts, and the difficulties encountered in reaching markets (some sections having only a monthly boat upon which shipments can be made), all combine to render the cost of production greatly in excess of that of mainland sections. Not the least of the drawbacks to agriculture in Hawaii is the multitude of insect enemies and plant diseases, the control of which, unchecked by freezing temperatures, demands continual vigilance on the part of the would-be producers who often fail to realize the necessity even for such precautionary or remedial measures as spray-

ing. The building up of a strong demand for locally grown products would do much to overcome the present situation, but it appears necessary to subsidize certain lines of agriculture before it will be possible to produce sufficient food to enable the people of the islands to exist if suddenly cut off from the mainland.

## BUILDINGS AND GROUNDS.

During the year a set of farm buildings, including a combination stable and barn and a 4-room residence for the substation foreman, was erected at the Castner substation. The type of construction of the barn is such that the attic is available for curing forage crop samples while the space beneath the first floor is utilized for the storage of implements. Inasmuch as there is no convenient supply of household water, redwood tanks have been installed to catch the rain water from the buildings.

## COOPERATION WITH MILITARY POSTS.

The national food emergency situation has led to the establishment of tracts for growing vegetables on a number of military reservations on the island of Oahu. In carrying out this work, the experiment station has been able to render material assistance in the selection of suitable soils, has made recommendations regarding crops to be grown, and in some instances has been able to supply plants and seed produced on the station grounds. On the Schofield Barracks reservation, over 100 acres of sod and guava land has been cleared and broken up and the larger part is already planted to cassava and sweet potatoes.

The forage crop work on Schofield Barracks reservation at Castner was definitely inaugurated July, 1916, and during the year a considerable number of forage and food-crop production experiments have been started. The principal difficulties encountered are lack of sufficient rainfall, the presence of strong winds, and the high manganese content of the soil. About 50 varieties of grasses, forage plants, and food crops are under test.

## HORTICULTURAL INVESTIGATIONS.

The growth and development of seedling pineapples has constituted an important line of work during the past year. Several thousand seedlings have been set out in individual pots, and as fast as these attain sufficient size they are transferred to cooperating plantations where they will be brought to fruit under regular field conditions. Through the cooperation of the Office of Foreign Seed and Plant Introduction, Bureau of Plant Industry of the United States Department of Agriculture, two varieties new to the islands have

been introduced, one the MacGregor from Queensland, Australia, which is said to be immune to the black heart disease; the other the Commonwealth, also from Queensland, which was developed from a seedling.

Recognition of the potential value of small home vineyards has led to the establishment of a cooperative vineyard of about an acre in extent where various fertilizer, variety, and cultural experiments are in progress. The principal work with avocados has been in connection with the development of a winter-ripening type with a rind sufficiently hard and tough for protection from the fruit fly and for profitable shipment. Seven different varieties of avocado have been introduced from California. A number of mango hybrids have been produced in an attempt to combine the several good qualities of the different varieties. One of the handicaps to tomato growing in the islands is attack by the melon fly. The small native tomato is immune to these attacks and hybrids relatively immune have been developed by crossing the native tomato with the Earliana variety. Thousands of seedlings from these hybrid plants are being grown throughout the islands and watched by several hundred individuals in connection with their cooperative home gardens. The most desirable individual plants will be used in the development of a relatively immune standard-size tomato.

## CHEMICAL INVESTIGATIONS.

As its most important line of work, the chemical division has been following up the preliminary results obtained from the spraying with iron sulphate of pineapple plants growing on manganese soil. Iron sulphate has been ordered in carload lots by a number of the local pineapple companies, the practice of spraying having been adopted wherever manganese soils occur in the pineapple plantings. Because of the presence of large quantities of manganese in the soil, a large acreage of otherwise good pineapple land has been allowed to stand idle in the past, but with the problem of counteracting the effects of manganese on pineapples solved, these areas are now being broken up and planted. Over 5,000 acres of manganese land was successfully treated with iron sulphate spray during the past year. Pineapple wilt is also giving considerable concern to local growers and a number of experiments on means of controlling the trouble are under way, the most promising of these appearing to be the application of suitable quantities of lime to the wlit-affected soils.

Fertilizer experiments with rice, banana, and pineapple have been inaugurated in cooperation with various growers throughout the islands. The present food shortage has made especially important the drying of such food products as would otherwise be lost from

decay if not used with reasonable promptness. Preliminary experiments have shown that locally grown cassava, sweet potatoes, taro, etc., can be readily dried by exposure to the sun and wind on suitably constructed driers, and that the resulting dried product can be stored without apparent deterioration.

## EXTENSION WORK.

The work of the extension division has been prosecuted along a number of lines employing several methods of approach. Timely articles in local newspapers have brought vital facts before the reading public. As the character of the regular station bulletins and press bulletins is such that they do not lend themselves readily to the promulgation of miscellaneous data on short notice, the station has begun to issue a series of extension bulletins, an important innovation, as in this way a channel is provided through which items of a general agricultural nature can be brought immediately to the attention of those interested. The manner in which these extension bulletins have been welcomed has furnished evidence of their usefulness. In addition to the above, numerous field trips have been taken by various members of the staff for the purpose of explaining and demonstrating improved agricultural operations such as spraying, budding, grafting, pruning, and garden management. Five demonstration farms, maintained cooperatively with the owners of the farms, have furnished numerous object lessons that appeal alike to the members of all races irrespective of color or language. The food-crop production campaign has called for much extra work on the part of those directly interested in the extension phases of the activities of the station. The manifest appreciation of this work has been gratifying. A decided stimulus to numerous lines of agricultural endeavor was given by the two agricultural county fairs in the success of which the work of the extension division was an important contributing factor.

## PLANT-DISEASE INVESTIGATIONS.

The division of plant pathology was installed at the station June 1, 1916, but most of its development has taken place during the past fiscal year. The division now occupies three rooms, namely, a combined office and library, a laboratory for microscopical and general work, and a separate gas-equipped laboratory room where culture media are prepared. The diseases of the potato, banana, and celery have received the greatest amount of attention during the season. The potential importance of the Irish potato crop, combined with the presence of several serious diseases, has made the potato-disease project the most important line of work of the division. The emer-

gency food-production campaign has led to repeated calls on the station pathologist for advice and assistance regarding the best means of overcoming the various plant diseases and insect pests of the garden. To supply this information, multigraphed sheets of directions have been prepared.

## GLENWOOD SUBSTATION.

The work of the Glenwood substation has been along poultry, dairy, and forage and food-production lines. Attention has been focused on the poultry work as it has proved the most profitable of any line of work so far inaugurated at the substation. Trap-nest and egg-weight records for the flock have been maintained throughout the year, affording the best possible basis for the selection of eggs for distribution for hatching purposes. The work with the edible canna has been continued and tubers from the original planting have been distributed throughout the islands in connection with the emergency food crop-production work. A number of different plantings of celery have indicated that with careful attention to spraying at the proper time the crop is reasonably certain when grown either under cloth or in the open.

Among the forage plants experimented with, the common bamboo grass has made a creditable showing under the adverse climatic conditions obtaining throughout most of the year. The ravages of cutworms make it difficult to establish a stand of alfalfa, but this difficulty can be overcome by transplanting well-grown seedlings to the rows in the field, as in transplanting tomato plants. Vigorous, isolated plants of alfalfa several years of age attest the possibilities of the crop when once established. A number of varieties of bur clover were tried with fair results. Not sufficiently erect in their habit of growth to allow easy cutting for green forage, the bur clovers are of most promise for use in pastures.

During the autumn of 1916 the substation maintained an active interest in the local county fair. This fair brought to light the "Hamakua hybrid," a very promising, relatively blight-resistant potato which is apparently a cross between a local Portuguese Red potato and some mainland variety, several of which were being grown in association with the Portuguese Red potato at the time of this discovery. Comparative tests for disease resistance were at once started at the substation, and the showing made by the new variety as compared with the mainland varieties was remarkable, the blight completely destroying the vines of the ordinary varieties a considerable time before the crop had fully matured, while the resistant variety was attacked only at a considerably later date and then not seriously. As comparative tests on the other islands have not shown such strik-

ing results as at the substation, for the time being most of the extension work with this new variety will be carried out on the island of Hawaii, where it appears to be of the most promise.

## AGRONOMIC INVESTIGATIONS.

The work of the agronomy division has been devoted to a continuation of experiments with rice, taro, potatoes, various leguminous crops, and forage grasses.

As its most important work, the agronomy division has established a substation at Castner, Oahu, on the Schofield Barracks reservation in cooperation with the military authorities. Plats have been laid out and tests of varieties, kinds and amount of fertilizers, and cultural methods have been inaugurated. These experiments were sufficiently under way to furnish much valuable information for use in connection with the emergency food and forage production work inaugurated in the spring of 1917.

## TERRITORIAL MARKETING DIVISION.

The total volume of business transacted by the division during the year amounted to $139,519.05, as compared with $121,085.78 for the preceding year. Consignments numbering 2,538 and consisting of 60 different kinds of island products, were received and sold. The number of different producers consigning to the division was 474.

The retail vegetable and meat branches, while not quite paying expenses, proved a most valuable adjunct to the wholesale consignment department in that they furnished an outlet at all times for the produce consigned by the small farmer. Before the establishment of the retail branches, it frequently happened that produce could not be sold to the local retail stores except at a great sacrifice. This was apparently because the island supply was not regular and dependable and retail dealers made standing orders for regular shipments each week from the mainland. These regular shipments were ordinarily sufficient to meet the needs of the retail customers and great difficulty was experienced in moving the locally grown produce.

In the autumn of 1916, agricultural county fairs were held at Hilo, Hawaii, and at Wailuku, Maui. Demonstrations were given at each of the best methods of grading and shipping island-grown produce of various kinds.

The recent session of the legislature appropriated $30,000 for the operating expenses of the division for the enusing biennium and also provided $5,000 for extension work among the farmers, looking to the standardization of products, improved methods of crating, etc. A revolving fund of $15,000 was provided to permit more prompt

payment of consignors. An additional revolving fund of $2,500 for the purchase of seed was also made available. On July 1, 1917, the Territorial marketing division was transferred to the Territorial Board of Agriculture and Forestry.

### PUBLICATIONS.

The following publications have been issued during the year:

Annual Report for 1916.

Bulletin 41, Phosphate Fertilizers for Hawaiian Soils, and Their Availability.

Bulletin 42, Composition of Hawaiian Soil Particles.

Bulletin 43, Chemical Studies of the Efficiency of Legumes as Green Manures in Hawaii.

Press Bulletin 51, The Spraying of Yellow Pineapple Plants on Manganese Soils with Iron Sulphate Solutions.

Press Bulletin 52, Comparative Value of Legumes as Green Manures.

Extension Bulletin 1, Extension Notes I.

Extension Bulletin 2, Extension Notes II.

## REPORT OF THE HORTICULTURAL DIVISION.

By J. Edgar Higgins.

The principal work of the horticultural division during the year was with the pineapple, avocado, mango, grape, and tomato, although the national food shortage emergency has called for considerable attention to variety and cultural tests with vegetables. James H. Cowan, who has been associated with the horticultural division since September, 1913, took up the projects left by Valentine S. Holt when he resigned from the station August 31, 1916.

### PINEAPPLE INVESTIGATIONS.

The seedling pineapples of station Nos. 3059 and 3060 have been fruiting since June, 1916. The seeds from which these grew were planted in October, 1912. It thus required three years and eight months from seeding for the first of these to mature fruit. While there have been very marked variations among these, as recorded in the annual report for 1916, none has thus far shown a combination of characters of sufficient desirability to justify the establishment of a new commercial variety. This, however, is not surprising or disappointing, as it would be quite remarkable for any new forms of unusual value to appear among so few chance seedlings as were included in these first two lots planted.

Seeds have been found in the fruits of these seedlings with undesirable frequency, giving rise to suspicion that seed bearing may be an inherited character in them. Such a conclusion, however, is not justified by the evidence in hand, for, although a large percentage of the fruits had some seeds, it is to be remembered that each seedling is more or less a distinct variety and may be subject to the effects of pollen from some of the neighboring plants, of the same or of different origin, while it may be wholly sterile to its own pollen. If this be the case, as is true in general of the Cayenne variety, the supposed progenitor of all of the seedlings grown from seeds collected at the pineapple canneries, then it would be possible to propagate any such seedlings by slips, crowns, or other asexual parts and, by segregating them from other varieties, to avoid seed production. As no variety of pineapple habitually producing seeds can be considered either for canning or for the fresh fruit market, it will therefore be necessary to examine the promising seedlings carefully in order to determine whether seed production is due to inherited character or to environment.

There are now under cultivation about 2,240 plants from seeds supplied by a number of pineapple canneries and planted during the winter of 1915–16. Of these, about 350 which had attained sufficient size were planted out in the pineapple fields, where they are under the same conditions as commercial plantings. During the past fiscal year all available pineapple seeds from the canneries have been planted, but seeds appear to have been of less frequent occurrence than during the winter of 1915–16.

A hundred or more hybrids or crossbreds now under cultivation were grown from seeds of a Cayenne plant, several of whose flowers had been fertilized with pollen from the Queen variety. No precautions were taken to prevent self-fertilization, as the rarity of this occurrence seems to indicate that such precautions are hardly necessary. Further crossing of pineapples had been planned, but had to be deferred on account of the pressure of work in connection with the food campaign during the most favorable hybridizing season.

Selections have been made in the fields of several hundred plants to be propagated by slips or by suckers to determine the constancy of certain characters under asexual propagation.

Two new varieties have been introduced through the cooperation of the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry. One of these is the MacGregor, a variety from Queensland, Australia, which is claimed to be immune to the black heart, a disease which resembles in many ways and may be identical with the brown rot of pineapples described by Larsen [1] and occurring

[1] Larsen, L. D. Diseases of the pineapple. Hawaiian Sugar Planters' Sta., Path. and Physiol. Bul. 10 (1910), pp. 28–36.

in Hawaii. The following notes concerning this variety are taken from the Queensland Agricultural Journal for February, 1916:

We have received from Mr. E. Smallman, Campsie Fruit Farm, Ormiston, the accompanying photograph of that portion of his orchard which is devoted to the cultivation of a special variety of pineapple which he obtained 10 or 11 years ago from what was known as Skyring's Farm, Bulimba. The plants are most prolific bearers, as will be seen by the illustration, which shows them in full bearing just before Christmas. These were only planted in September, 1914, and a single quarter acre yielded 2,500 pines, averaging about 4½ pounds each in weight. One of the specially good qualities of the fruit is that it keeps well and never develops "black heart." A case of the fruit was sent to Sir William MacGregor, late governor of Queensland, 12 months ago, and he expresses his unqualified opinion of the pines as the finest in flavor and texture that had come under his notice when in Queensland. Mr. Smallman brought two very fine specimens to this office, each of which went over 4½ pounds and not picked samples. They were quite ripe but very firm in the flesh, and their flavor quite deserved all that Sir William MacGregor said of them. There having been only one plant originally obtained it took several years' planting of "nibs" and tops before the present area was fully planted and bearing.

Plants of the MacGregor variety were supplied by J. F. Bailey, of the botanic gardens of Brisbane, Australia.

The other variety introduced is the Commonwealth, secured through R. W. Peters, director of the Queensland Acclimatization Society. This is one of the society's seedlings and is understood to be of much promise in Australia. Both of these lots of plants arrived by mail in good condition, having been packed dry.

## GRAPE EXPERIMENTS.

In connection with investigations of fruits suited to tropical conditions, some experiments were undertaken in the growing of grapes. The grape has long been under cultivation in Hawaii, chiefly by the Portuguese settlers, to whom is probably due the credit of having introduced the variety which has been most successful in these islands, supposedly a strain of the Isabella, which is reported to have been introduced on an immigrant ship arriving here from Madeira. Though grapes of other varieties have been introduced from time to time, none has established itself in the islands except the one just referred to, an indication merely that this variety is very hardy and resistant to disease, as probably there are many other varieties which can be made to prosper. Small vineyards are to be found in many parts of the Territory, particularly in the vicinity of Honolulu and Hilo, in the district of Kona, Hawaii, and in Makawao and the lower slopes of Haleakala on the island of Maui. Near Honolulu and the other important towns a considerable portion of the crop is consumed as fresh fruit, selling at 10 to 12 cents per pound retail. A small wine industry has grown up at several points, but

the Isabella variety is not particularly adapted to wine purposes, as it is apparently necessary to fortify it heavily to prevent deterioration.

With the rapidly increasing population of the island of Oahu and the growing demands of steamships calling at the islands, there appears to be an opportunity to increase the trade in fresh grapes. As little experimental work has been done on the grape in Hawaii, it seemed desirable to embrace an offered opportunity to undertake a cooperative experiment on a small scale which would make it possible to attack some of the problems relating to this minor industry, Willard Brown, of Wahiawa, Oahu, supplying the land, labor, and fertilizers, the experiment station furnishing the plants and giving advice on their care and cultivation. A little vineyard of about one acre in extent, located at Wahiawa about 26 miles from Honolulu, at an elevation of approximately 1,100 feet, on a clay loam soil with a rather retentive subsoil, was set in March, 1916, with plants at distances of 8 by 10 feet. Only the Isabella variety was used, it being intended to graft upon these plants any other varieties which later might be introduced into the experiment, for, as mentioned above, this variety has proved well adapted to local conditions and the limited experience of the past indicates that the few other varieties tried have done better on Isabella roots than on their own.

*Fertilizer experiments.*—One of the first problems which it seemed desirable to investigate was that of fertilizers. For this purpose the vineyard was laid off in three divisions, as indicated in figure 1. In divisions 1 and 2 certain combinations of two of the fertilizing elements were applied, while division 3 was treated with a complete fertilizer, with the exception of rows Nos. 13, 14, and 15, which were left unfertilized, row No. 14 being held as a check. All fertilizers were applied on March 14, 1916.

In division 1 there were 10 plants in each row, and in division 2, 9 plants. The first and last plants in each of the fertilized rows in division 1 were left without fertilizer and also the first plant in each fertilized row in division 2, thus leaving two unfertilized plants to separate the fertilized rows of division 1 from those of division 2. This is indicated on the chart (fig. 1) by a break in the line.

In division 1 the 8 plants from No. 2 to No. 9, inclusive, in row No. 2 received 2 pounds of nitrate of soda, or the equivalent of one-fourth pound per plant. This was at the rate of only 136 pounds of nitrate of soda per acre distributed evenly over the entire area. Since the plants set out were small, with roots only a few inches long, the fertilizer was applied exclusively to the hole, about 3 feet in diameter at the surface, in which the plants were being set. If the whole area had received fertilizer equivalent to that applied to the feeding area, the amount would have been several times that indicated above.

The corresponding 8 plants in row No. 5 of this division received 2 pounds of sulphate of ammonia, or the equivalent of one-fourth pound per plant. In row No. 8 the application was 4 pounds of blood, or the equivalent of one-half pound per plant. The corresponding 8 plants of row No. 11 received 4 pounds of sulphate of potash, or the equivalent of one-half pound per plant. Two rows were left unfertilized between each two fertilized rows. Row No. 13 was therefore 16 feet from any fertilized plants, and, although an outside row, it could fairly be taken as a check, since the land beyond for 20 feet or more was cultivated, as well as that imme-

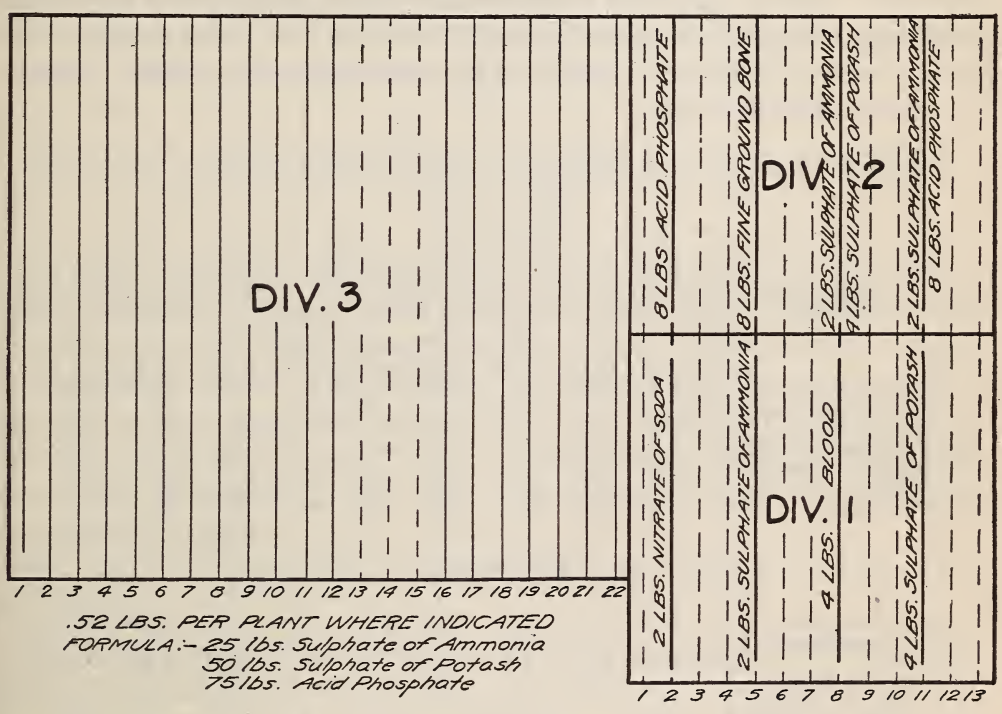


FIG. 1.—Chart of vineyard, showing fertilizer experiments. The heavy lines indicate fertilized rows and the broken lines unfertilized rows.

diately surrounding the plants. Also this row was on the side away from the prevailing winds.

In division 2 the last 8 plants in rows Nos. 2, 5, 8, and 11 were treated with fertilizer. Row No. 2 received 8 pounds of acid phosphate, or the equivalent of 1 pound per plant; row No. 5, 8 pounds of finely ground steamed bone, or the equivalent of 1 pound per plant; row No. 8, 2 pounds of sulphate of ammonia and 4 pounds of sulphate of potash, or the equivalent of one-fourth pound and one-half pound, respectively, per plant; row No. 11, 2 pounds of sulphate of ammonia and 8 pounds of acid phosphate, or the equivalent of one-fourth pound and 1 pound, respectively, per plant.

In division 3, with 16 plants to the row, a complete fertilizer consisting of 25 pounds sulphate of ammonia, 50 pounds sulphate of

potash, and 75 pounds acid phosphate was applied at the rate of 8.32 pounds per row, or the equivalent of 0.52 pound per plant. Rows Nos. 13, 14, and 15 were left unfertilized, only row No. 14 being considered as a check, however, since there was a possibility that the plants in rows Nos. 13 and 15 might use the fertilizers from adjoining rows.

*Summary of results of fertilizer tests.*—In divisions 1 and 2 measurements were made on December 14 of each plant in the fertilized rows and in the check row. In the case of division 3, all plants in row No. 14 were measured and also the plants of an average fertilized row. In all cases the total length of the plants was measured, including the growth made prior to setting out (the plants were fairly uniform at that time). The accompanying tables indicate the effects of fertilizing:

*Comparative growth of fertilized and unfertilized grapevines, Mar. 14 to Dec. 14, 1916.*

DIVISION 1.

| Row No. | Fertilizer applied per plant. | Plant No. 1. | Plant No. 2. | Plant No. 3. | Plant No. 4. | Plant No. 5. | Plant No. 6. | Plant No. 7. | Plant No. 8. | Total growth. | Average growth. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* |
| 2 | Nitrate of soda, 1/4 lb. | 3 9 | 6 3 | 11 7 | 6 | 1 3 | 2 7 | 8 | 8 | 27 3 | 3 4.8 |
| 5 | Sulphate of ammonia, 1/4 lb. | 4 0 | 10 | 0 | 6 | 0 | 9 | 5 | 6 | 7 0 | 10.5 |
| 8 | Dried blood, 1/2 lb. | 1 9 | 2 1 | 0 | 7 | 1 2 | 7 | 6 | 0 | 6 8 | 10.0 |
| 11 | Sulphate of potash, 1/2 lb. | 1 1 | 0 | 11 | 0 | 9 | 8 | 10 | 0 | 4 3 | 6.3 |
| 13 | Unfertilized | 4 | 7 | 10 | 6 | 6 | 0 | 4 | 2 2 | 5 3 | 7.8 |

DIVISION 2.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | Acid phosphate, 1 lb. | 12 0 | 25 6 | 1 3 | 8 10 | 10 10 | 7 0 | 4 5 | 15 0 | 84 10 | 10 7.2 |
| 5 | Fine ground bone, 1 lb. | 46 4 | 53 10 | 3 0 | 19 0 | 23 5 | 16 5 | 2 0 | 17 2 | 181 2 | 22 7.7 |
| 8 | Sulphate of ammonia, 1/4 lb., sulphate of potash, 1/2 lb. | 7 | 0 | 10 5 | 15 0 | 11 4 | 7 | 8 | 9 | 39 4 | 4 11.0 |
| 11 | Sulphate of ammonia, 1/4 lb., acid phosphate, 1 lb. | 4 | 11 0 | 1 10 | 8 3 | 8 | 6 0 | 18 8 | 18 8 | 65 5 | 8 2.1 |
| 4 | Unfertilized | 3 0 | 9 4 | 22 3 | 11 0 | 7 | 2 4 | 0 | 3 11 | 52 5 | 6 6.6 |

*Comparative growth of fertilized and unfertilized grapevines on division 3, Mar. 14 to Dec. 14, 1916.*

| | Plant No. 1. | Plant No. 2. | Plant No. 3. | Plant No. 4. | Plant No. 5. | Plant No. 6. | Plant No. 7. | Plant No. 8. | Plant No. 9. |
|---|---|---|---|---|---|---|---|---|---|
| | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* |
| Fertilized row | 3 6 | 6 10 | 3 0 | 12 11 | 12 0 | 5 0 | 19 7 | 19 11 | 17 0 |
| Unfertilized row | 10 | 6 | 7 | 11 | 2 5 | 3 | 1 4 | 6 9 | 3 8 |

| | Plant No. 10. | Plant No. 11. | Plant No. 12. | Plant No. 13. | Plant No. 14. | Plant No. 15. | Plant No. 16. | Total growth. | Average growth. |
|---|---|---|---|---|---|---|---|---|---|
| | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* | *Ft. In.* |
| Fertilized row | 27 0 | 17 2 | 7 7 | 18 4 | 13 4 | 6 3 | 9 2 | 198 7 | 12 4.0 |
| Unfertilized row | 3 3 | 0 | 11 | 0 | 1 3 | 1 5 | 1 8 | 25 9 | 1 7.3 |

The increase of growth produced by sulphate of ammonia and by dried blood was almost negligible, and while in the nitrate of soda row there was an increase of nearly 3 feet, it will be observed that this growth was not at all uniform, the results justifying slight confidence in using nitrate of soda alone as a fertilizer. Apparently nitrogen is not the dominant need of grapevines on this soil, or else certain limiting factors render the use of nitrogen alone of very little benefit.

As potash used alone in the form of sulphate failed to produce any beneficial results, it may be concluded that limiting factors other than potash were operative in this case also.

It will be seen that 1 pound of acid phosphate per plant produced a fairly uniform increase in the growth of the plants, which averaged 10 feet 7 inches in length, while where ground bone was used at the rate of 1 pound per plant the increase was much greater, these plants averaging 22 feet 7 inches in length (Pl. I, fig. 1). Since fine ground bone contains more than 22 per cent of phosphoric acid, while acid phosphate contains only about 15 per cent, the greater increase in plants treated with 1 pound of bone is perhaps accounted for by the fact that these plants each received a much larger amount of phosphoric acid. The presence of approximately 4 per cent of nitrogen in the bone may also have had a beneficial effect, but by referring to division 2, row No. 11, it will be seen that nitrogen added to the acid phosphate in the form of sulphate of ammonia produced no beneficial results.

The effect of phosphoric acid and potash without nitrogen was not tested.

The complete fertilizer used in division 3, which contained only about 0.26 pound acid phosphate per plant, produced greater growth than did 1 pound of acid phosphate alone. This would seem to indicate that some of the benefits following the use of the mixed fertilizer must have been due to either the potash or the nitrogen, or to both.

One of the most striking features of these tests as a whole was the complete failure of most of the unfertilized plants, many of them having failed even to live.

It is fair to conclude from the above that for the successful growing of crops phosphoric acid in liberal amount must be applied to the type of soil used. Further experiments are now under way to determine more accurately the requirements in the way of potash and nitrogen in combination with the necessary phosphoric acid.

*Pruning.*—On January 30 and 31 all the vines on the experimental plats were pruned by cutting back, leaving about two buds of the preceding season's growth. Some bleeding followed, a more or less

common occurrence in this climate where there is no cold weather to arrest the flow of sap. To give the vines the best possible chance, grafting wax was applied on March 1 to each of the wounds.

*Trellising.*—In Hawaii practically the only type of support for grapevines is the overhead arbor trellis adopted by the early Portuguese growers, this being the type with which they were familiar in Madeira, where the grapes of Hawaii originated. It has not been determined whether any of the other systems of trellising are better adapted to local conditions. The arbor system, while it has certain advantages, has perhaps greater disadvantages, such as its expensiveness and the impossibility of standing erect under the average trellis or of cultivating with horse or mule. It was decided to try what is usually known as the Munson 3-wire trough trellis, the cost of materials for which is little more than a third that of the usual overhead arbor of wood. The Munson trellis consists essentially of three wires separated by cross arms on upright posts, the central wire being a few inches lower than the other two. The vines are trained along this central wire, and the new growth each season falls naturally over the outer wires. The upright posts, which are placed twice, or in some cases three times, as far apart as the plants, according to their arrangement, may be 20 to 24 feet apart, and it is necessary that the end posts be well braced to prevent their being pulled over by the strain. The wire used on the trellis which was constructed during April, 1917, was No. 10 for the center of the trough and No. 12 for the outside.

*Control of Japanese beetle (Adoretus umbrosus).*—The Japanese beetle is one of the most important insect pests of grapes, particularly where they are grown in very restricted areas. With only a few plants in a home garden, these beetles will frequently consume the entire foliage. Many means have been employed in the attempt to control this insect, not only on grapes but on the very large variety of plants upon which it feeds.

The method which has perhaps proved most effective among the small growers of grapes in and about Honolulu has been hand picking at night when the insects are at work on the foliage and can be found with lanterns. The adult beetles feed exclusively at night, the daylight hours being spent beneath the surface of the soil or in other hiding places away from the light. Hand picking is tedious and expensive but is often done on small areas where the pests are not too numerous. A fungus disease has proved a decided factor in the control of this beetle in rainy sections and also during the rainy season in all parts of the islands. The use of arsenical poison for the control of this pest has not found great favor, but as no thorough tests of its use have been reported the station decided to undertake some systematic trials on grapevines growing in cans. These have

given very promising results which are reported upon by James H. Cowan, as follows:

Although few definite data have yet been obtained concerning the protection of grapevines in the vineyard against the attacks of the Japanese beetle, an experiment on a very small scale was carried on at this station during the early part of the year 1916 with encouraging results. Seventy grapevines, all of the same variety and of the same age and size, were used. These vines were grown in tin cans and were so arranged as to form seven rows equally distant one from the other, the distance of the plants in the rows being equal to the distance of the plants between the rows. The rows were labeled A, B, C, D, E, F, and G, reading from left to right. Row A was sprayed with an arsenical spray consisting of 1 pound of a powdered form of arsenate of lead to 5 gallons of water. Row B was left unsprayed as a check. Row C was sprayed with a proprietary brand of arsenate of lead that is sold in the paste form and is claimed to be very adhesive. This was used in the proportion of 1 pound to 10 gallons of water. Row D was left unsprayed as a second check. Row E was sprayed with another brand of arsenate of lead also sold in the paste form, and this was used in the proportion of 1 pound to 10 gallons of water. Row F was a third check, and row G was sprayed with the same brand of arsenate of lead as was used in row A only in the proportion of 1 pound to 10 gallons of water. Plate I, figure 2, shows an average plant of each row except row A, where the results were not distinguishable from those of row E. The photograph was taken six days after the application of the sprays. On the morning following the day on which the plants were sprayed almost every unsprayed plant had been slightly riddled, while those which had been sprayed were untouched. The rain during the second night almost completely washed off the spray on rows A and G. Observations during the evenings also indicated that there were fewer beetles at work during the rainy evening than on the following dry nights. A few dead beetles were found in rows C and E on the third, fourth, and fifth mornings. When the photograph was taken on the sixth morning the plants in row C were the least eaten and the spray on these appeared to be as much in evidence as on the day when it had been applied. Row E was next in degree of protection, the plants on an average being nearly as well protected as those in row C, but the spray was beginning to lose its adhesiveness. The plants in rows A and G were at this time eaten about 25 per cent more than those in C, due to the fact that they had lost about 90 per cent of the spray.

It would appear that a very high degree of protection from these insects can be given to grapevines by the use of rather strong doses of arsenical sprays. One of the most important features of a spray for this purpose in a tropical country with frequent showers is the adhesiveness of the preparation.

## AVOCADO INVESTIGATIONS.

There are now in the plant houses and ready for orchard planting several hybrid avocados, resulting from the crossing of an unnamed but very promising seedling of Guatemalan type (avocado series No. 160) with pollen from four varieties of West Indian avocados, some of which are very rich but are not well protected by a tough or

hard rind. The Guatemalan type is characterized by a thick, woody, or corky rind which gives it ample protection from external injury, but fruits of this type are not equal in richness to some of the varieties used as pollen parents. The West Indian varieties tend to fruit in the summer and early autumn, while the Guatemalan, although variable in season, usually mature between November and March. If a winter-fruiting avocado having high oil content and excellence of flavor, combined with a protective rind, can be originated, it will be a genuine acquisition, but a summer-fruiting variety with a tough rind would be of somewhat less value. It must be remembered, however, that toughness of rind is not the only factor entering into good keeping qualities, as in some fruits there is a breaking down of the tissues from within entirely apart from any external injury.

The collection and description of varieties and their propagation have been continued by Mr. Cowan. About 30 seedlings of local origin have been described and are being made the subject of further investigation. The records consist of descriptions of the fruits, outline drawings with preserved specimens when possible, and all available data regarding the trees. As all varieties are being scrutinized as carefully as possible before being listed, it is not to be expected that many of the large number of sorts under test in Hawaii, California, Florida, and elsewhere will prove commercially successful. Although there is no desire to lengthen the list of varieties for general planting in this or other avocado-growing countries, it is thought that there can hardly be too many promising forms under trial, from which, however, an active process of elimination must sift all but a very few which reach the highest commercial standard.

There have been introduced during the year through the kindness of Joseph Sexton, of Goleta, Cal., seven varieties attracting much attention in that State, where avocado growing is rapidly developing into an important industry. These varieties, with the Hawaii Station division of horticulture accession numbers, are as follows: Taft (No. 3834), Atlixco (No. 3835), White (No. 3836), Blakeman (No. 3837), Colima (No. 3838), Lyon (No. 3839), El Fuerte (No. 3840).

## MISCELLANEOUS BREEDING INVESTIGATIONS.

There are now in the plant houses several young mango trees believed to have been produced by cross-pollination. These crosses were made by Valentine S. Holt, formerly assistant horticulturist, who states that the flowers were all carefully protected from any accidental pollination. It is hoped with some confidence that they are not the result of multiple germs or adventitious growths, as none of them has been observed to send up more than one stem from a seed. The crosses include Scott×Pirie, Kavasji-Patel×Pirie, Java×Pirie, Paheri×Pirie, Pirie×Alphonse, and an unnamed variety×Pirie.

FIG. 1.—EFFECT OF FERTILIZERS ON GROWTH OF GRAPEVINES.
Central row received ground bone; checks on either side, nothing.

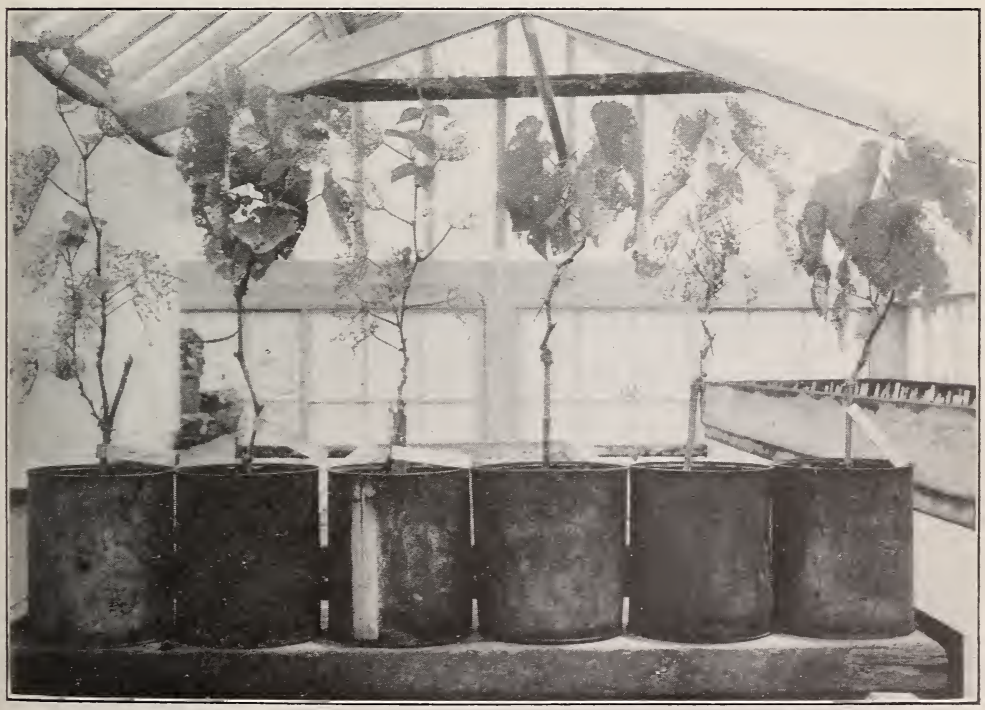

FIG. 2.—EFFECT OF ARSENATE OF LEAD ON CONTROL OF JAPANESE BEETLE.
Alternate vines unsprayed.

FIG. 1.—WASTE LAND CLEARED AND TENDED BY STATION EMPLOYEES AFTER OFFICE HOURS.

FIG. 2.—FRONT YARD GARDEN NEAR HONOLULU.

EMERGENCY GARDENS.

In connection with papaya breeding there is little to report at this time. It is interesting to note that the excellence of flavor which characterized one of the original selections has now been transmitted through three generations in a large proportion of the offspring. There is also an encouraging ratio of bearing to nonbearing trees.

Other breeding work under way includes the crossing of certain varieties of tomatoes in an effort to secure a strain combining sufficient size with resistance to the melon fly (*Dacus cucurbitæ*), which is a great menace to tomato growing in Hawaii. Some attempts have also been made to hybridize certain species of Eugenia.

## CACAO CULTIVATION IN HAWAII.

In March, 1917, the Legislature of the Territory of Hawaii, then in session, requested the station to supply a statement on the possibilities of cacao growing in Hawaii. The following notes on the subject were prepared, including data on the history of this tree in these islands and, since they may serve as a record to date and also as a reply to such inquiries which arise from time to time, they are incorporated here.

*Climatic and soil requirements.*—In order to get a clear understanding of the possibilities and limitations of cacao culture in Hawaii, it is necessary to consider the natural requirements of this crop. Cacao is strictly a tropical plant, being injured by climates in which the temperature repeatedly falls below 60° F., although an occasional fall of this kind is not prohibitive to its growth. Liberal moisture in the soil is imperative, and in practice this is usually supplied by rain, irrigation not often being resorted to. It is difficult to give any figures adequately expressing its requirements in the way of soil moisture, since so much depends upon the distribution of the rainfall through the year and the water-holding capacity of the soil. Most of the successful cacao-growing countries have a rainfall of more than 70 inches per year, which, however, would be insufficient if it were unevenely distributed or if the trees grew in soils retaining their moisture badly. On the other hand, excessive rain at harvest interferes with the curing of the beans. Another prerequisite is shelter from winds, strong winds being exceedingly destructive to the interests of the planter.

*Trials of cacao in Hawaii.*—The late Dr. Hillebrand, who lived in Hawaii during the 20 years preceding 1871, probably introduced the cacao tree in Hawaii, a specimen still surviving on the property planted by him on Nuuanu Avenue, Honolulu, and now owned by Mrs. Mary E. Foster. Other trees of comparatively early introduction or planting are to be found in various parts of the islands, notably in and about Hilo, trees about Honolulu having been less successful. Some years ago there were a number of trees at Ahuimanu ranch on

windward Oahu, some of which are probably still producing. The promise of success given by the trees in the vicinity of Hilo led the station at one time to introduce more plants for trial in the Hilo district, an experiment being undertaken some years ago in cooperation with the Hilo Boarding School, which had to be given up on account of lack of funds. A few of the trees, however, which have survived and have been cared for by the school appear to be in a healthy condition. They are reported to yield fairly well and the pods which have been received at the station are good specimens.

*Prospects in Hawaii.*—The tree begins to bear fruit about the fourth year after planting, and increases in production for several years. The yield of an established cacao plantation runs from 300 to 600 pounds per acre. The prices of the different grades at the present time range from $11 to $16 per hundredweight, the latter being commanded by the product of only the finest varieties, which, in turn, do not yield the maximum crop. The present high prices are not likely to continue, and for calculating returns, $10 to $14 per hundredweight would be as high as it would be safe to expect, which would make the gross receipts per acre run from $30 to $84 per year.

As curing cacao is a process which does not require elaborate machinery or expensive equipment, the crop in this respect is well adapted to the use of small growers who may be quite widely separated. In addition the beans, when cured, are not a highly perishable product. This makes it possible to grow cacao on comparatively cheap lands at considerable distances from the world's markets and with the cheap labor so prevalent in most tropical countries. Hawaii, therefore, would have to meet strong competition in marketing the raw product. By reason of its nearness to markets and its good transportation facilities, Hawaii could counterbalance this disadvantage by entering the field of manufacture—a thing not yet attempted generally by countries far from the consumer.

The data in hand indicate that any attempts to establish cacao growing as an industry in Hawaii should be confined to localities near sea level, and only those sheltered places which are warm and moist are to be considered. Sheltered spots in Hilo and Puna, in general, offer the best locations for further trials. The Hana coast of Maui presents some advantages.

Through the cooperation of the Hilo Boarding School, the station will soon be able to secure a limited supply of seed, and will gladly assist any who wish to make further trials of cacao in promising localities by supplying such plants as may be available.

*Methods of cultivation.*—The cacao tree grows to a height of 15 to 25 feet and produces its fruit or pods on the trunk and main branches. The tree is propagated from seeds, which must be planted

while fresh, as they retain their viability for only a short time in the pod and perish almost immediately if removed from the pod. These seeds are usually planted in nurseries, and the young plants removed to their permanent location when about six months old. Some growers prefer to stake off the plantation and plant the seeds by the stakes, which represent the permanent location of the trees. Though grafting and budding have not been generally practiced with cacao, the tree is adapted to this method of propagation, which is now receiving some attention as a means of establishing plantations of high yield and of greater uniformity in product. Cacao is generally grown with shade, preferably leguminous trees, which also furnish protection from wind, a more important function than that of giving shade. Some temporary shade is usually provided by rapidly growing plants, such as bananas, until the permanent trees are well grown.

The ripe pods, from 6 to 12 inches in length, are picked by means of a tool not unlike a reaping hook. They contain about 30 seeds or "beans," surrounded by a mucilaginous substance, which are removed promptly and placed in heaps or in vats to ferment. The heaps are turned over at intervals during fermentation, the process being completed in from 2 to 10 days according to the conditions. The seeds or "beans" are then washed and are exposed to the sun for a short time each day until dry to preserve their plumpness, which would be lost if the drying were completed immediately by one exposure. These dried beans—the product from which cocoa and chocolate are made—are then ready to be bagged and shipped to market. Usually the manufacturing of chocolate and cocoa is not carried on in the countries where the cacao is produced, doubtless because the beans are so much more easily shipped.

## FOOD-PRODUCTION WORK.

There was a very marked increase of interest in all branches of food production during the year. In encouraging and establishing such work the horticultural division has taken an active part in every way possible. The movement was given a strong impetus by the school garden and home garden contests conducted by the Honolulu Star-Bulletin. As a member of the board of judges of these contests, the horticulturist came into close contact with the movement on all parts of the island of Oahu, all the school gardens having been visited at least twice and many of the home gardens on one or more occasions. The contests had a very marked influence in stimulating interest in the production of vegetables, the children conducting gardens not only in the school yards and those surrounding their homes but in many cases on ground nearly a mile away,

traveling back and forth on foot to keep their growing crops in good condition. The influence extended to neighboring homes and as a result of the presence of some successful pupil's garden in the vicinity, it has been common to find gardens springing up about homes which have no children at school.

All this work was a fitting preparation for the emergency food campaign which started vigorously in the latter part of the third quarter of the year and continues at the present time. The need for larger national production is being emphasized here, with special reference to the undesirably large importation of the foodstuffs which are consumed in these islands. Vegetable gardens have sprung up everywhere and larger plantings of the staple vegetables such as sweet potatoes, Irish potatoes, and beans are in evidence in many places. (See Pl. II, figs. 1 and 2.) The division of horticulture has been able to render some assistance in this work by means of addresses before various organizations desirous of acquiring knowledge of methods of growing food crops and a short series of lectures given to the Women's Navy League.

It was also the privilege of the division to cooperate with the other branches of the station, especially the extension division, in the preparation of a planting chart, giving in very condensed form essential data regarding all the vegetable crops that may be grown in Hawaii. In addition to requests for information which it was possible to furnish through letters or publications to groups of individuals and organizations, many inquiries were received which necessitated personal visits to lands under consideration for food production, as those of the Boy Scouts and others who contemplated planting on a much larger scale. The volume of inquiries by telephone and letter also was much greater than usual during this period, a fact indicating the very large increase of interest in the growing of crops in Hawaii.

There has also been a great demand for plants, and the station has distributed in small numbers to each individual such plants as were available and which could be expected to give an early return. These distributions have included many hundreds of plants of tomatoes, papayas, roselle, sweet potatoes, etc.

## BULLETINS FOR PUBLICATION.

The manuscript for a bulletin on the Litchi in Hawaii was submitted for publication in the early part of the year.[1] Another manuscript relating to the cultivation of the banana as a source of food supply is in process of preparation.

[1] Hawaii Sta. Bul. 44 (1917).

### EXTENSION WORK.

In addition to the extension activities mentioned elsewhere, the horticulturist, with J. B. Thompson, superintendent in charge of the Glenwood substation, spent about two weeks in the interests of this work on Hawaii, chiefly in Kona, during which time James H. Cowan, of the horticultural division, took temporary charge of Mr. Thompson's work at Glenwood. The horticulturist also attended the Maui County Fair, judging horticultural products and also assisting in connection with the experiment station exhibit. Later in the year another trip was made to Maui partly in the interests of extension work and partly in connection with pineapple investigations.

### ADDITIONS TO EQUIPMENT.

No extensive additions were made to the equipment. A steam sterilizing plant was installed for the treatment of soils for use in the greenhouses and propagating yards. Two overhead systems of irrigation are being tested in these yards. As opportunity offers, a collection of specimens of fruits in preservative fluids in museum jars is being made by Mr. Cowan.

## REPORT OF THE CHEMICAL DIVISION.

By Maxwell O. Johnson.

During the past year the work of the chemical division has been continued largely along the lines indicated in the report for 1916. The problem of successfully growing pineapples on the highly manganiferous soils of Hawaii appears to have been solved commercially by spraying the plants with solutions of iron sulphate. Further investigations are being made of the scientific aspects of this problem. The work on the wilt of pineapples has been continued and a number of experiments laid out. Some work has been done on the fertilizing of bananas, rice, and pineapples. Preliminary experiments have been made on the drying of food crops. As the assistant chemist has been on furlough during the entire year the work of the chemical division has been necessarily somewhat curtailed.

### INVESTIGATIONS ON THE MANGANIFEROUS SOILS OF HAWAII.

The most important work of the past year was the practical development of the iron sulphate spraying treatment for overcoming the very injurious effects of the highly manganiferous soils on pineapples. A preliminary announcement of results was given in the annual report for 1916. Further results have more than justified expectations. A popular discussion of the results secured in field

experiments by the iron sulphate spray and practical advice as to the treatment of manganiferous soils were issued during the past fiscal year in a press bulletin of this station.[1] The application of small quantities of an approximately 8 per cent solution of iron sulphate (32 pounds of copperas to 50 gallons of water) in the form of a fine mist appeared to be most effective and economical. An article on the scientific phases of this problem was also published during the past fiscal year.[2] In order to clear up some doubtful technical points, further investigations of the effects of manganese in a series of water cultures have been started which promise to throw some light on this question as well as on the relation of manganese and iron. The results will be further confirmed by pot cultures.

As a result of these experiments all the Hawaiian pineapple plantations have now adopted the sulphate of iron spray for pineapples on manganiferous soils. Statements recently secured from the larger companies show that 5,094 acres of pineapples are being sprayed by them at the present time. In addition to this acreage, there are in the aggregate considerable areas belonging to smaller growers which are being sprayed, and also much new manganese land is being put into pineapples at the present time, largely by reason of the fact that a practical means of overcoming the manganese difficulty has been discovered. The readiness with which this new procedure has been adopted is evidence of its practical value.

During January, 1917, a trip was made to the island of Lanai, at present devoted to ranching, to investigate its possibilities for pineapple production. The chief agricultural lands of this island consist of about 20,000 acres lying in a saucerlike depression at an altitude of about 1,000 feet. The soil contains considerable manganese dioxid and on it small plantings of pineapple show the typical "manganese yellows." It is very probable that if this large area of potential pineapple land is ever brought under cultivation for that crop the iron-sulphate spray will be necessary for profitable results.

## INVESTIGATIONS CONCERNING THE PINEAPPLE WILT.

The investigations on the Kauai wilt of pineapples were continued. The wilting is more widespread than was at first thought, and it is a very serious problem to the pineapple growers on the windward side of Oahu and also on the mauka (upland) soils on the leeward side of the Koolau Range. The dying back of pineapples on the island of Maui also seems to be a form of wilt, but the collapse of the plants is less rapid.

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[1] Hawaii Sta. Press Bul. 51 (1916).

[2] Johnson, M. O. Manganese as a cause of the depression in the assimilation of iron by pineapple plants. Jour. Indus. and Engin. Chem., 9 (1917), No. 1, pp. 47–49.

From present evidence regarding the wilt, it appears to be a root rot partly due to lack of drainage and partly to high acidity or sourness of the soil, the more serious form being associated with the yellow or yellowish-brown soil derived from volcanic ash. A number of field experiments have been laid out in an effort to overcome this trouble, but the plants have not yet matured sufficiently to permit definite conclusions as to the value of the various remedies under trial.

### SPRAYING OF FERTILIZER ON RICE, BANANAS, AND PINEAPPLES.

The success met with in spraying with iron-sulphate solutions has led to spraying experiments with other fertilizers. The maintenance of a continuous food supply to the plant by spraying with a small amount of fertilizer at frequent intervals would appear to be a more logical method of fertilization than the application of a large amount of fertilizer before planting, as in the latter case the fertilizer is more subject to loss by leaching and by fixation by the soil. Preliminary cooperative experiments are being conducted with bananas, rice, and pineapples, the results of which will be published later.

### CHEMICAL STUDIES OF LEGUMES AS GREEN MANURES.

In connection with the project on the chemical study of legumes as green manures, which was completed during the fiscal year 1916 by Miss Alice R. Thompson, assistant chemist, numerous analyses were made of the nitrogen content of a number of varieties of legumes grown under identical conditions. These results have been recast and with the aid of field data furnished by C. A. Sahr, assistant agronomist, as to the yields of the legume varieties, it has been possible to make a general comparison of the relative efficiency of the different varieties of legumes in furnishing nitrogen to the soil. The results of this work were issued during the past fiscal year as a press bulletin of this station.[1]

### THE DRYING OF FOOD PRODUCTS.

As the national food shortage during the present year has rendered any method of food preservation important, the station has undertaken experiments on the drying of food products under Hawaiian conditions. With the strong trade winds and the many relatively clear days, the simplest and most economical method of food preservation appears to be drying by the sun. Preliminary experiments having shown that cassava, taro, sweet potato, and other food products can be dried very easily by this method, a small drier has been built to secure practical data on the problem.

[1] Hawaii Sta. Press Bul. 52 (1917).

## REPORT OF THE EXTENSION DIVISION.

By F. G. Krauss.

The extension division of the station is now in its third year, and it is believed that the services thus far rendered to the farmers of Hawaii have fully justified its establishment. The research work of an experiment station is only completed when its findings are expressed in terms which the farmer can put to practical use. It is the function of the extension division to interpret by actual demonstrations, or other acceptable methods, technical and often obscure work not only of State experiment stations but of the United States Department of Agriculture and other agencies not always accessible to the lay farmer.

### DEMONSTRATION AND ADVISORY WORK.

Whenever it has been posssible, and to the full extent of its resources, the extension division has arranged cooperative experiments in testing new and improved crops, better cultural, feeding, and marketing methods, cost accounting systems, and in such other work as modern agricultural development has seemed to warrant. On the whole a very satisfactory response has come from both small and large farmers in their willingness to try out new crops and better cultural methods. This is especially true in the matter of forage crops, to which the extension division has given particular attention. At the substation and demonstration farm at Haiku, Maui, tests are made on a field scale of all promising crops sent out by the Hawaii Experiment Station and by the United States Department of Agriculture, as well as those collected from other sources (Pl. III, fig. 1). Different cultural methods (Pl. III, fig. 2), including green manuring and fertilizing, intercropping, and crop rotations have been tested and comparisons made of seasons for planting, rates of seeding, methods of selective breeding and harvesting and curing crops, and in a number of cases, their effects when fed to live stock.

To the extent of its means, modern farm implements and machinery have been added to the equipment of the substation.

The agricultural community and all interested persons have been invited to visit the extension-division farms, and many have responded. It is estimated that between four and five hundred visitors came to the substation at Haiku during the past year, which, in view of the limited number of persons engaged in diversified farming on Maui, is thought to be of considerable importance. The superintendent is frequently called into consultation by the farmers, and makes many excursions to give advice of an agricultural nature. The correspondence is also large. Occasional contributions are made to the press, a total of some 30 articles on agricultural subjects having

been prepared during the past year, besides several manuscripts for bulletins.

Large quantities of seeds and plants have been distributed throughout the Territory, most of which were grown at the substation at Haiku. Besides stimulating the production of new and better crops, this distribution is expected to lead to the accumulation of many important data, as applicants have been requested to report upon the results of their experiments. In so far as it has been found feasible the farm equipment of the substation, such as seeders, thrashing outfits, etc., has been made available to the community.

Possibly the most important feature of the work of the year has been the close cooperation between the extension division and specialists in the various branches of agriculture. This has permitted the reference of special problems to those most capable of their solution. All departments of the Federal experiment station have rendered valuable aid to individual farmers as well as to the extension division.

## FORAGE AND GREEN MANURING CROPS.

Recognizing early in its work the importance of local production of at least a part of the expensive feedstuffs hitherto imported from the mainland, the extension division set about growing on a field scale the more promising forage crops, both at the demonstration farm at Haiku and in cooperation with farmers. The progress of this work up to last year was reported in the last annual report of the station. During the fall of 1916 and spring of 1917 about 40 acres was devoted to leguminous and nonleguminous forage crops. The legumes include 12 varieties of cowpeas, 4 of velvet beans, 2 of peanuts, 6 of soy beans, and 4 each of alfalfa, pigeon peas (*Cajanus indicus*), and jack beans (*Canavali ensiformis*).

A dozen or more of the above varieties have now found a permanent place in Hawaiian agriculture. Among the most prominent are the Brabham and Iron varieties of cowpeas for forage and green manuring purposes, the Groit and Taylor varieties for seed, and the Whippoorwill as a general-purpose pea. While only fractional acre plats of the above were grown in the trial grounds three years ago, several hundred acres was planted in the Haiku district this spring. Among the velvet beans the Brazilian variety is now taking the lead, and all available seed has been planted. Of the half dozen varieties of peanuts grown several years ago, the Improved Valencia has become standard. The jack bean and pigeon pea are well established. Sunn hemp, owing to the expense of harvesting the seed, is not as promising as it formerly seemed to be, although it is still of promise for green manuring and as a possible fiber plant. Soy beans give uncertain results, but the great value of the crop justifies a continuation

of experiments with them. The alfalfas on the raw uplands do not thrive, but of some 10 varieties under test the smooth Peruvian and hairy Peruvian varieties give the greatest promise. All varieties have responded to liberal manuring and fertilizing with phosphate, but liming and artificial inoculation appear to have been without beneficial effects.

Among the grasses, the Japanese cane is giving excellent results, and large acreages are being planted (Pl. III, fig. 1). The same to a somewhat less extent is also true of Sudan grass and Australian grass (*Paspalum dilatatum*). Of these three grasses the Japanese cane and the Paspalum are preferable, mainly because of the susceptibility of Sudan to rust, especially in moist locations. However, Paspalum is chiefly pasture grass.

Corn culture, as in the past, has received much attention because of the importance of the grain. The production of 100 bushels, 5,680 pounds of shelled grain, from an acre has set a new mark for Hawaii. When it is taken into account that the land upon which this crop was grown produced only about 35 bushels in its virgin state, the importance of the agricultural methods adopted will be better appreciated. The corn grown was an early maturing yellow dent variety developed by the substation at Haiku from Funk's Ninety Day, Reid's Yellow Dent, and Gold Standard Leaming. The soil, a medium loam, had received some 60 tons of green manure in the course of three years, and at seeding 500 pounds of high-grade fertilizer was drilled into the rows, which were spaced 30 inches apart. The season was fairly favorable, there being ample moisture, but strong winds prevailed during a large part of the growing period. In an adjacent plat, with all other conditions identical except the spacing, the rows being 60 inches apart, slightly less than half the yield of the 30-inch rows was obtained. The theory is that, there being optimum fertility and moisture to develop the closely planted crop, the close planting provided better protection against the strong winds than did the wide planting. The present spring crop just being harvested, following a dry season, is yielding at the rate of about 70 bushels per acre with rows spaced 60 inches apart. This corn is intercropped with sweet potatoes and received no fertilizer other than the green manure referred to above. The present price of small yellow dent corn in the Honolulu market is $73 to $78 per ton. It will thus be seen that a 70-bushel, or 2-ton, corn crop is profitable farming, although the cost of production per acre approaches $75.

Numerous varieties of grain sorghums and millets, together with buckwheat and sunflower seed, were tested with a view to determining the most profitable sorts to grow for chicken feed. A number

of varieties found promising will be given further trial. An acre plat of sunflowers produced 700 pounds of clean seed, which, at $3 per 100, was grown at a loss, but it should be noted that the land upon which this yield was obtained failed to produce ear corn and that certainly no other crop would have produced as favorable results under the conditions as did the sunflowers.

Eighteen varieties of cereals, including wheat, oats, barley, and rye, were tested in cooperation with the station. The ryes proved totally unsuited to conditions. The other three grains set seed and are worthy of further trial. As catch crops for hay, especially during the present period of high prices of feeds, it seems quite probable that the cereals might be made profitable.

White and sweet potatoes continue to receive much attention at the substation and demonstration farm at Haiku. Of the eight varieties of Irish potatoes with which work was started three years ago, a superior strain of Bliss's Triumph has been developed, and this now appears to be firmly established in the Kula potato district. The experiments and demonstrations in spraying potatoes with Bordeaux mixture, carried on in cooperation with the pathologist of the station, have given definitely favorable results on the summer crop in the Makawao district, over 50 per cent increase in yields having resulted from spraying alone. At present prices this increased production is valued at over $100 per acre. Since the Kula and Makawao potato is one of the three most important staples of the district, a vigorous spraying campaign will be undertaken in connection with the fall potato crop. A project is also being planned for cooperative experiments in better cultural methods, including the introduction of better seed.

Since the establishment of headquarters for the extension division at Haiku, Maui, one of the important centers of the pineapple industry, much cultural work has been done with this crop. During the past year the importance of planting only selected plants, whether crowns, slips, or shoots, has been fully demonstrated. As plants have been in great demand in recent years, planters have been inclined to plant any and all available stock regardless of its source or quality, but the low vitality of the resulting progeny has been a most potent factor, though not the only one, in producing the many ills of the pineapple grower. Fortunately, growers generally are recognizing the truth of this contention, which is readily demonstrated.

Another important practice inaugurated by the extension division is that of subsoiling between the pineapple rows and maintaining practically a flat culture rather than the deep furrowing and high hilling commonly employed in the wetter districts. The method used at the substation is to subsoil between the rows as soon as the plants

have become established and to follow with a middle burster, which throws out the soil to either side, many weeds being destroyed by this operation. In a week or 10 days the soil is thrown back into the furrow by the use of a special 15-tooth cultivator having the tooth bars slightly curved so as to leave the space between the rows a little dished. The subsoiling, middle bursting, and cultivation is repeated four times during the first year's growth, after which it is no longer possible to work between the rows. As a result of this practice, the soil is broken up to a depth of approximately 18 inches between the rows without bringing the subsoil to the surface, good drainage is secured, and a deep, loose foraging ground provided for future root development, and this at a time when the plant is in greatest need of expansion. By the old method, the plants were left perched on hard, baked ridges, with the possibility of fullest development only in very favorable seasons.

Drainage experiments conducted in porcelain pots as well as in the field indicate strongly that many pineapple troubles are due to a stagnant condition of the soil, as regards both air and water, a conclusion which the results from the subsoiling and mulching experiments tend to confirm.

Fertilizer experiments carried on for several years have thus far given results too inconclusive to warrant a report other than that reverted phosphate appears to be the most beneficial treatment yet tried. A series of liming experiments in cooperation with the station chemist is now under way in the Haiku district.

As a valuable adjunct to diversified farming on the islands, the extension division is furthering the swine industry by maintaining a small herd of registered Berkshire swine at the substation at Haiku, where it is planned to develop a modern pig plant for demonstration purposes. Farm-grown feeds are used in large part. A portable hog cot, with built-in self-feeder devised by the substation, has been widely copied by the hog raisers on the island of Maui and elsewhere, while a successful demonstration in home ham and bacon making just completed has already stimulated enterprise along the line of a more rational farming than has hitherto been practiced by the small farmer of Hawaii.

An important advance in agricultural development was made when Hawaii and Maui Counties inaugurated their annual agricultural fairs. Maui County's first fair, held November 30 to December 2, 1916, was actively supported by the extension division, which not only fostered the enterprise, but gave exhibits and demonstrations.

Four collaborators are maintained on the different islands whose duty it is to render "first aid" in their respective districts. The superintendent keeps in touch with these by occasional visits and

FIG. 1.—JAPANESE CANE AS A FORAGE CROP AT HAIKU.

FIG. 2.—EXPERIMENTAL TILLAGE FIELD AT HAIKU.

FIG. 1.—ROWS AT LEFT SPRAYED ONCE WITH BORDEAUX MIXTURE, ROWS IN CENTER NOT SPRAYED.

FIG. 2.—CENTER ROWS SPRAYED, OUTSIDE ROWS NOT SPRAYED.

FIG. 3.—POTATOES PILED FOR COMPARISON.

POTATO SPRAYING EXPERIMENTS.

correspondence. The newly formed Territorial Food Commission supplements the work of the extension division, forming an important link between the producer and consumer, and the several Government agencies work in close cooperation for the development of a better agriculture for Hawaii.

### UTILIZATION OF LOCALLY GROWN FOOD CROPS.

There are in Hawaii a great number of races and nationalities which have brought with them and still maintain a preference for the food used in the countries from which they came, most of which has to be imported from the country in question. Greater utilization of the food crops that are or can be grown in Hawaii would, it is felt, do much toward overcoming the tendency to import such a great proportion of locally used foodstuffs. With a view to increasing the utilization of local foods, the extension division, with the cooperation of the other branches of the station and the wives of various members of the station staff, has done active work in emphasizing the various methods by which the native and introduced food crops can be prepared so that they can practically replace the imported articles. At both the county fairs held during the year numerous samples of preserved native fruits were exhibited to show that they constituted an excellent substitute for the imported product. Through various women's organizations, the substitution of locally available food crops for similar imported ones has been actively fostered both by actual demonstrations at fairs and special meetings and by articles in agricultural and home-economics sections of the local papers.

## REPORT OF THE DIVISION OF PLANT PATHOLOGY.

By C. W. Carpenter.

During the past year the plant pathology division was established and a laboratory equipped in a suitable manner for the investigation of plant diseases and the study of fungus and bacterial organisms. The office and laboratory formerly occupied by the division of entomology in the main office building were used with but slight changes. Owing to the fact that this building is not fireproof, it was considered inadvisable to install gas. To meet the needs of the new division, one of the small insectary buildings was moved to a position in the rear of the main building and fitted up as a laboratory kitchen, and though rather small this furnishes a complete one-room laboratory suitable for the preparation of culture media and for other operations requiring gas. In equipping the pathological laboratory, expensive equipment of a specialized nature has been avoided and will be until the need of such apparatus shall have presented itself.

At the inception of the work of the new division, it seemed desirable to become familiar with Hawaiian agricultural conditions as quickly as possible. To this end the problems which presented themselves were taken up in turn for a preliminary investigation with no idea of making an exhaustive study at the time. Every opportunity has been utilized to get in touch with the problems in the field where observations could be made at first hand.

The experience of the year shows that there is in Hawaii a fertile field for pathological investigations and that there are a number of questions of sufficient economic importance to justify critical study. There is also need of considerable extension work along the lines of food conservation through disease and insect control. This phase of the work has been receiving a major portion of the time of the division since the announcement of a threatened national shortage of food. Circular letters have been prepared for correspondents concerning the preparation of Bordeaux mixture and other sprays, disinfecting dips for seed potatoes, poison baits for cutworms, and the fumigation of stored products. To aid further in the conservation of food crops, an emergency bulletin of a popular nature on Methods of Combating Garden Pests has been submitted.[1]

A number of plant diseases have been observed during the past year and in some cases the causal organism has been cultured and identified. In most cases the organism has not been subjected to an exhaustive study, the species being determined either from familiarity with the organism or from comparison with descriptions by various authors of organisms of the same genus and from the same host plants. In case of a well-known disease, it is believed that there is little chance for error in reporting its occurrence here if the typical signs are present on the same host and a similar fungus of the same genus is associated with the disturbance. It is expected that organisms associated with the more important diseases will receive critical study as opportunity permits.

## DISEASES OF THE IRISH POTATO.

Many years ago the growing of Irish or white potatoes was a much more important industry in Hawaii than it is at the present time. Ships stopping here replenished their supplies with Kula potatoes, many of which were taken to California and around the Horn to the Atlantic seaboard. During one year 71,000 barrels are said to have been shipped. As a result of some condition or combination of circumstances, the potato industry has become relatively unimportant, although considerable quantities are still raised. It is

[1] Hawaii Sta. Ext. Bul. 4, Emergency Ser. II (1917).

believed that the diseases affecting the potato are the most potent factor in discouraging potato growing.

Until the division of pathology was established at this station, the diseases of the potato in Hawaii seem not to have been critically studied nor were the causes of the troubles determined. In a publication of this station,[1] without date, but probably issued in 1903, T. F. Sedgwick discusses certain preliminary experiments with the "quick blight" of potato. The disease as there described does not coincide with any one disease as observed by the writer but seems to have been a confusion of the two diseases, Fusarium wilt and late blight. The following is quoted from the description:

> The disease often wipes out whole fields of potatoes in a short time * * *. This disease of the potato has been confounded with the potato rot, but they are entirely different both in the cause and in their effect upon the plant. Until a better name is given we shall call it the "Quick Blight" of the potato * * *. Reports upon the disease from the Division of Pathology, Washington, D. C., indicate that it is caused by a Fusarium fungus * * *. The casual observer might not detect the disease until long after the destruction has begun, as there is little to indicate its presence. The vines usually make a good thrifty growth and seem to be healthy until shortly after blossoming, when without warning, the leaves and stem wither, turn black, and die to the ground as though bitten by frost.

Since the wilt disease caused by *Fusarium oxysporum* is prevalent in the section of Maui where Sedgwick carried on his varietal tests, it seems probable that this was the disease he had reference to, as possibly fields of Fusarium infected plants became attacked by late blight, such a combination of diseases being not uncommon in Kula. His preliminary experiments were not conclusive and apparently no further work was done.

*The late-blight disease.*—Serious trouble with the potato crop was probably first experienced when the late-blight disease (*Phytophthora infestans*) was introduced. Just when this happened has not been determined. The only mention found of this disease in Hawaii is in a report of May, 1913, of a pathological inspection trip on Hawaii by L. D. Larsen. In speaking of potato failures he says, "All indications point to the late blight (*Phytophthora infestans*) as the responsible factor." It is stated that no speciments were obtained for examination.

There is some ground for belief that *Phytophthora infestans* became serious in Maui about 1890. It is certain that this disease is now prevalent in the potato sections of Hawaii, Maui, and Oahu, but whether it occurs on the other islands of the group there has been no opportunity to determine. It is interesting to note in this connection that *Phytophthora infestans* has been reported as destructive

[1] Hawaii Sta. Press Bul. 3.

in other tropical and subtropical countries, Butler[1] and Dastur[2] reporting it in India where, according to the latter, it is prevalent only in the hills, and Jehle[3] reporting it in Cuba where it is said to destroy annually a large part of the crop.

In some sections of the islands, as in the vicinity of Glenwood, Hawaii, the weather is ideal for the development of Phytophthora every month in the year. In the Kula section of Maui and in the vicinity of Castner, Oahu, where there is considerably less rain, an outbreak can be expected at almost any time after a rainstorm or in a period when misty showers are of frequent occurrence. Although in general there may be said to be seasonal plantings of potatoes, about two main crops a year being common, the various periods of growth so overlap that growing vines and typically blighted plants can be found at any time somewhere in the islands.

Usually during the warmer part of the year, this disease is confined to the mountain slopes and cooler valleys, but a typical outbreak was observed at Mokuleia, Oahu, at sea level about April 13, which, however, made no progress during a week of dry hot weather. Some of the plants were sprayed April 20. Subsequent to spraying there was considerable rain on two different days. When examined about two weeks later, the unsprayed plants were badly diseased, the stems standing erect but the leaves rotting or drying up, while the sprayed plants were only slightly affected, presenting a striking contrast to the unsprayed rows. (See Pl. IV, fig. 1.)

A considerable number of demonstration sprayings of potatoes with 5:5:50 Bordeaux mixture have been made both on Oahu and on Maui, from which it appears that this disease can be largely prevented by proper spraying. It is being recommended that plants be sprayed first when 6 to 8 inches high and about every two weeks thereafter and after rains, or, in other words, often enough to keep the plants, and especially the new growth, continuously protected. The blight generally appears shortly after the time of blossoming.

Where it has been possible to properly conduct and supervise the spraying demonstration experiments, the results have been highly satisfactory. In the Kula section of Maui, where the demonstration of effective control methods would be of the most benefit, the distance from Honolulu and the difficulty of getting to the section have made it almost impossible to give the fields the attention needed. In consequence, heavy showers having in nearly every instance washed off the spray mixture a few days after it was applied, and the necessary

[1] Butler, E. J. Potato diseases of India. Agr. Ledger, 1903, No. 4 (Crop Disease and Pest Ser. No. 7).

[2] Dastur, J. F. The potato blight in India. Mem. Dept. Agr. India, Bot. Ser., 7 (1915), No. 3.

[3] Jehle, R. A. Late blight of potato. Estac. Expt. Agron. Cuba Circ. 48 (1915), pp. 2–6.

cooperators not having been secured to make further applications at critical times, the results in this section have on the whole been less satisfactory than might otherwise have been the case. Because of this experience the work of demonstrating the use of Bordeaux mixture for the control of the late blight will be continued in Kula in cooperation with the extension division, under more auspicious circumstances than last year.

The data from a spraying experiment conducted at Castner, Oahu, are summarized as an indication of what results may be expected from the intelligent use of Bordeaux mixture in controlling the late blight disease. The plat of potatoes under experiment consisted of 4 rows of 60 hills each. The seed was inspected and planted January 19 and the plants of the two inside rows were sprayed March 17, 19, and 27, altogether less than 10 gallons of 5:5:50 Bordeaux mixture being used. The tubers were dug April 10. (See Pl. IV, figs. 2 and 3.) The yields of the two rows of unsprayed plants were, respectively, 66 and 78 pounds, and for the sprayed plants, respectively, 110 and 116 pounds, a total weight of 226 pounds from 120 hills of sprayed plants and of 144 pounds from the same number of hills of unsprayed plants, the gain being 82 pounds, or 57 per cent. The blight was already well started when spraying was begun and blight-favoring weather continued for a relatively short period after the spray was applied. The experiment, therefore, was not conducted under the best conditions for maximum beneficial effect of the spray mixture. The spray material for the 120 hills cost about 20 cents, and the value of the increased yield at the market price of potatoes at the time was $4.10.

After the spraying of potatoes with Bordeaux mixture has become a general practice and the late blight is controlled or prevented to as great an extent as possible, attention will be directed to other diseases of this crop whose annual ravages are very serious. The full extent of the loss caused by these other diseases is unappreciated, the spectacular effects of late blight masking the injury due to the more insidious diseases.

*Fusarium wilt disease.*—The Fusarium wilt disease caused by the fungus *Fusarium oxysporum* was observed repeatedly in the fields about Waiakoa, Maui. The organism was isolated and identified from the discolored vascular bundles of the stems of wilted plants and from the vascular ring of young tubers from the same plants. The organism has also been repeatedly isolated and identified from California potatoes coming into the territory, both as seed and table stock. Before this disease can be controlled to any extent a source of disease-free seed will have to be found and much fundamental work done in establishing seed selection and crop rotation as general practices.

The characteristic signs of the wilt are not difficult to recognize. The plants grow well for some time—often until about the time of flowering—when they appear to suffer as from a shortage of water. The leaves droop and the margins may roll upward, the wilting effect being more noticeable at midday and partial recovery during the night being common. The leaves later become lighter green or slightly yellowed and gradually dry up, the plant dries prematurely, and the tubers do not reach full size.

The disease is brought about by a fungus, *Fusarium oxysporum*, growing in the vascular ducts of the stem and roots and mechanically interfering with the movement of water. If the underground stem of affected plants is split, the woody portion often shows a brown discoloration. Similarly, paring away the stem end of affected tubers often discloses a discoloration of the vascular ring. It is generally believed that the fungus continues to grow along the vascular bundles of the tuber after it is dug, and if such a tuber is used for seed the parasite grows directly from it into the new plant.

The measures, all of a sanitary nature, suggested for lessening the damage done by this disease on the mainland will quite probably be of value here. These include hill selection of seed, healthy plants being staked during the growing period, and the progeny of those plants remaining healthy being reserved for seed; and cutting off at planting time a thin slice at the stem end of tubers and discarding those lots of seed any considerable number of which show a brown discoloration at this point. Such selected seed should be planted on new soil or on soil which has not been in potatoes for at least three years. For the best interests of the potato industry each grower should maintain his own seed plat. All undesirable plants should be rigidly pulled or rogued out and the progeny of the best yielding, disease-free strains saved for seed.

*Rosette disease.*—The rosette disease caused by *Rhizoctonia solani* is more or less prevalent in all fields thus far seen. Where the main stems of potato plants are girdled by this fungus at or below the soil surface a rolling of the leaves often results. Such affected plants as observed here are usually only slightly dwarfed and present a somewhat straggling or spreading appearance. The leaves tend to roll upward and become light green or yellowish, and the forming tubers are collected on very short stolons in a bunch near the main stem. Small aerial tubers also occur.

The treatment for this disease consists in sanitary measures. It is probable that the fungus is carried by the seed in the form of the small sclerotia which adhere closely to the skin of the tuber and resemble a bit of dirt or soil. Seed selection, disinfection of seed in corrosive sublimate solution, and crop rotation are all important precautionary measures.

*Scab diseases.*—Common scab occurs in the islands, but no serious infection of tubers has yet been observed. The majority of the scab and skin blemishes observed are of the sort generally attributed to Rhizoctonia and to injuries brought about by the tuber moth (*Phthorimæa operculella*), wireworms, and cutworms.

*Storage rots.*—Potatoes grown in Hawaii are seldom stored for any length of time, as the fact that the entire crop of the islands is now such a small part of the total amount consumed favors immediate use of the home-grown product. Yet considerable loss, especially in seed stock, is brought about by the action of the late-blight fungus (*Phytophthora infestans*), the wilt fungus (*Fusarium oxysporum*), and the root-inhabiting fungus (*F. radicicola*), the two latter as wound parasites of the tubers.

As the porous soils in Kula dry out rapidly after a rain and the surface layers become heated in the sun, there is relatively slight damage from tubers rotting in the ground with the late blight fungus. Considerable loss in shipment to market is undoubtedly due to this sort of rot and to the secondary invasions which follow the late blight lesions.

*A mite disease of potatoes.*—A disease of potatoes, the cause of which is as yet not certainly established, is very prevalent and destructive on Oahu in hot weather. It was observed to begin early in May in the vicinity of Honolulu and about the middle of June at Castner. The disease is characterized by the withering and drying up of the new terminal growth and that in the leaf axils, the petioles also eventually becoming withered and dried. The stems remain erect with all the leaves dry and drooping. The trouble appears to be most prevalent in dry, hot weather, and most commonly attacks plants at the time of flowering. Examination of the slightly affected new growth, underneath the leaves of which there is usually a browning or bronzing as an early symptom, shows the presence of a quantity of mites and sculptured eggs. The mites are oval, of a slightly yellowish-brown color, the young having three pairs of legs, the adults four pairs. They are so small as to be almost invisible under a hand lens of a magnifying power of less than 20. Attacked new growth is also slightly more hairy or fuzzy than normal. The plants die in a short time (about 10 to 20 days) if seriously attacked. Whether the mites are entirely responsible for the trouble or only constantly associated with it remains to be determined.

This disease somewhat resembles the trouble described by Rolfs[1] on tomatoes in Florida, under the name Phytoptosis. Further studies of this disease and the identification of the mite by a specialist may suggest a better name for the trouble. The disease is very common

[1] Rolfs, P. H. Florida Sta. Buls. 21 (1893), pp. 23, 24; 47 (1898), p. 143.

in the vicinity of Honolulu and is the most destructive trouble after the weather becomes too warm and dry for late blight.

Rolfs suggests as a remedy for the tomato disease the use of dry sulphur or sulphur in Bordeaux mixture where the latter is being applied for this or other troubles. In the experience of this division, plants regularly sprayed with Bordeaux mixture alone were not badly attacked until about two weeks after the unsprayed plants in adjoining rows were infested. The Bordeaux apparently acts to some extent as a repellent.

## BANANA DISEASES.

*An Hawaiian disease of the banana.*—A serious disease of the Bluefields variety of bananas (*Musa sapientum*) was observed on the plantation of T. Ikeda, near Hilo, Hawaii, in June, 1916, at which time all the plants in a projecting corner of the plantation comprising about one-fourth acre were badly diseased and many were dead. When the plantation was visited about six months later, the disease had involved the entire planting of bananas, about 3½ acres. The trouble resembles the Panama disease as described by Ashby[1] and Drost.[2] On plants about three-fourths grown the disease caused drooping and drying of the lower leaves and breaking of the leaf-stalks with a sharp angle near the pseudostem (see Pl. V, fig. 1), sometimes buckling and falling over of the plant at the ground level or at some point higher up on the pseudostem, yellowed and browned vascular traces more or less widespread throughout the plant (as evidenced in cross and longitudinal sections of several entire plants), and occasional cavities of soft, ill-smelling rot. The discoloration of the vascular elements is traceable from the stem of the bunch and from the base of the expanded portion of the leaves or crown through the pseudostem to the bulb, and in some cases to rotted brown areas of the larger roots. These rotted areas of the roots are observed to penetrate the root cortex to the central portion, and the discoloration extends along this central portion of the root for some distance beyond the surface lesion. The fruits, where these are present, are incompletely developed, withered, and useless, with the fingers blackened, those at the apex of the bunch being smaller and less developed than those nearer the plant.

A fungus of section Elegans of the genus Fusarium was isolated in an aseptic manner from the interior of three different plants and at heights from the ground varying from 1 to 7 feet. The diseased plants were cut and suitable pieces of the pseudostem taken to the

[1] Ashby, S. F. Banana diseases in Jamaica. Bul. Dept. Agr. Jamaica, n. ser., 2 (1913), No. 6, pp. 95–149.

[2] Drost, A. W. De Surinaamsche Panamaziekte in de Gros Michel bacoven. Dept. Landb. Suriname Bul. 26 (1912). (Translated in article by S. F. Ashby.)

FIG. 1.—DISEASED BANANA PLANT, SHOWING DEAD AND DROOPING LEAVES.

FIG. 2.—DISEASE OF CHINESE BANANA CHARACTERIZED BY ROTTING OF CENTRAL LEAVES.

FIG. 1.—BAMBOO GRASS (PANICUM PALMIFOLIUM) AT GLENWOOD.

FIG. 2.—CANADA FIELD PEAS AT GLENWOOD.

laboratory, where the outer leaf sheaths were removed and dissected with sterile instruments, bits of discolored vascular strands being transferred to synthetic and beef agar plates and to tubes containing sterile plant stems, steamed rice, and potato cylinders. In a few cases bacterial contaminations were found, but the Fusarium generally developed in pure culture. The cultures were plated and reisolated.

The normal conidia of the Fusarium isolated by the writer are predominantly triseptate and, as above noted, are of the typical Elegans type. The cultural characters, that is, red coloration on steamed rice, blue sclerotia on potato cylinders, and salmon-colored pionnotes on sterile plant stems, also place the fungus in this section, which contains species with conidia of the same shape and comprises all of the vascular parasitic Fusaria. The Fusarium isolated here is considered identical with the one described as Fusarium A by Ashby. Sometime ago he sent the pathologist of this station, while the latter was still at Washington, D. C., subcultures of his Fusaria A and B for identification. His Fusarium A was reported as similar to *Fusarium vasinfectum* and Fusarium B was identified as *Fusarium radicicola.* Unfortunately, no cultures of Ashby's Fusarium A are available at the present time for exact comparison with the Hawaiian strain.

The disease as observed here differs from that described by Ashby in that the discolored vascular bundles are yellow and brown rather than red, in this respect resembling more the so-called Surinam Panama disease. The outer leaf sheaths were not observed to split to the ground as noted by Ashby and Drost.

G. L. Fawcett described a disease of the Chamaluco banana (*Musa paradisiaca*) in Porto Rico,[1] which also appears to be identical with the Hawaiian disease. A Fusarium said to be similar to Ashby's Fusarium A was found constantly associated with the trouble, but that it is the cause of the disease is not considered established.

*Other diseases of bananas.*—Among the other diseases of bananas there may be mentioned a disease of the Chinese variety (*Musa cavendishii*) characterized by a rotting of the young leaves while yet unrolled (see Pl. V, fig. 2), which is at times quite a serious trouble. If the tops of affected plants are removed soon enough with a cut well below the affected region, the plants frequently grow up in a healthy manner. The symptoms of the disease suggest the possibility that it is related to the so-called "moko" disease described by Rorer.[2]

Green fruits of the Chinese banana are attacked in wet weather by a disease causing the surface to become covered with minute grayish spots which later turn black. As the spots increase in size and number they coalesce and disfigure the fruits with a continuous black

[1] Porto Rico Sta. Rpt. 1915, p. 36.

[2] Rorer, J. B. A bacterial disease of bananas and plantains. Phytopathology, 1 (1911), No. 2, pp. 45–49.

coating. In itself the disease is not serious, as the interior of the fruit is not harmed, but diseased fruits do not keep well and are not accepted for export. Considerable loss is in this way incurred. The black spots appear to be acervuli of a Glœosporium-like fungus.

### DISEASES OF MISCELLANEOUS PLANTS.

The diseases most frequently encountered on economic plants in Hawaii are caused by Glœosporium-like fungi, the majority perhaps being due to the same species. That this fungus will prove to be the imperfect stage of a Glomerella is to be expected after the fundamental work of Shear and Wood[1] with this confusing group. Thus far a Glœosporium-like fungus has been found associated in Hawaii with diseases of the following plants: Avocado, banana, cassava, coffee, fig, guava, litchi, mango, star apple, and vanilla.

Other diseases of importance which have been observed are as follows: On the bean, anthracnose (*Colletotrichum lindemuthianum*); cauliflower, a bacterial rot of the inflorescence; celery, late blight (*Septoria petroselini apii*); sweet potato, scurf (*Monilochætes infuscans*), soft rot (*Rhizopus* sp. and *Fusarium solani*), and leaf spot (*Septoria bataticola*); and tomato, leaf blight (*Septoria lycopersici*) and *Phytophthora infestans*.

## REPORT OF THE GLENWOOD SUBSTATION.

By J. B. Thompson.

In the Glenwood section the past year has been one of the most trying periods in the history of diversified farming. The dairymen and poultry men are buying imported feeds and are paying prices 60 to 100 per cent higher than those paid one year ago, while the returns from their products have not kept pace with this increased cost of production. The cost of food, clothing, and all general necessities of life has advanced correspondingly, a condition adding to the already heavy burdens of the people and strongly emphasizing the importance of a system that will tend to augment home production, not only of stock feeds, but of table foods as well.

### FORAGE CROPS.

The future of the Glenwood district seems at the present time to depend very largely upon the development of the dairy industry, while the development of that industry appears to be contingent upon the substitution of home-grown feeds for a portion or all of the expensive imported feeds that are now being used. The successful and profitable production of any of the ordinary grains is not espe-

[1] Shear, C. L., and Wood, Anna K. Studies of fungous parasites belonging to the genus Glomerella. U. S. Dept. Agr., Bur. Plant Indus. Bul. 252 (1913).

cially promising in view of the heavy rains and the attendant difficulties in handling these crops, especially at the stage when the grain is approaching maturity. The production of a more adequate supply of nutritious green forage affords greater promise, and all prominence consistent with the resources at hand has been given to this line of the station work.

*Paspalum dilatatum*, or Paspalum grass, has continued to show good general results, but determinations of actual yields, or, more logically in the case of a pasture grass, trials that would indicate the grazing capacity of a given area, have not been found possible. An extension of the substation's plantings on an area of approximately $1\frac{1}{5}$ acres was made in October, 1916, this tract being laid out in rows 30 inches apart and root divisions planted in these rows at intervals of 18 inches. The ground upon which this planting was made having been previously plowed and prepared, the combined operation of digging and dividing the roots and completing the planting required the entire time of one man for a period of nine days. With labor at the rate of $1.50 per day, the cost of planting alone amounted to $11.25 per acre, but when the permanent nature of this grass when once established is considered this expense does not appear to be excessively high. As the year's plantings are on soil of unusually low fertility the grass has made correspondingly slow growth, but at this time (eight months after planting) it shows a fair crop of pasture and a good crop of seed. The seed crop will be allowed to remain in the field in order that the germination of this seed where it falls at maturity may hasten improvement in the stand of this grass.

*Panicum palmifolium*, or *Chætochloa palmifolia*, the common bamboo grass of the islands, has been grown at the substation as a forage plant for the past two years and it has been found to possess considerable merit. This grass is sometimes grown in Hilo and its vicinity as an ornamental plant and it may also be observed in an uncultivated state throughout the island. Late in the season of 1915, F. G. Snow, of Glenwood, Hawaii, furnished the substation with two undivided root clumps of this grass, and from this stock sufficient material has been propagated for planting an area of approximately 3,000 square feet. This species having the habits of a bunch grass, divisions of the root clumps are grown with the greatest ease. It is also a most prolific seed bearer (Pl. VI, fig. 1). The seeds which fall to the ground at maturity germinate, giving young plants of rather slow growth during their earlier stage, but of increasingly rapid growth as the root system develops. The leaf sheaths and to a less extent the leaves themselves have stiff, bristly hairs that are unpleasant to laborers who cut and handle the crop, as they pierce the unprotected skin of the hands and wrists, leaving

a disagreeable if not an extremely painful prickling sensation. This trouble may be avoided by wearing gloves while handling the green grass. At the substation this grass has been given reasonably clean cultivation on soil treated with fairly liberal applications of stable manure, under which conditions it promises to yield very satisfactory crops even during the cold season of the year when pasturage is scarce and most grasses make indifferent growth. Near the close of the year, a crop harvested from a small area yielded at the rate of 23.5 tons per acre. That the green grass is extremely palatable to stock and cattle is proved by the fact that this grass was cropped to the ground by animals gaining access to the experimental plats on February 17, while many other accessible crops, including red, white, crimson, peavine, and alsike clovers, growing in adjacent plats were left undisturbed.

Canada field peas have given full promise of success when planted during the cool season of the year on soil treated with heavy applications of stable manure. A garden plat seeded on November 20, 1916, made a remarkably vigorous growth, the vines running to a length of six feet or more (Pl. VI, fig. 2) and bearing a heavy crop of peas. On December 28, 1916, a planting was made on a well-manured field plat, the results from which compared favorably with those from the earlier field planting. Later plantings, in which commercial fertilizers were substituted for stable manure, were less successful, and the question remains to be answered as to whether these results were due to a warmer season of growth, or to a less favorable influence of commercial fertilizers, or to both. In an effort to study the fruiting habits of the pea under the climatic conditions obtaining at Glenwood, the tests have been continued beyond the soiling crop stage and no attempt has been made to obtain data relative to yields. Peas were borne in profusion, most of them developing well past the green-pea stage, but much loss due to excess moisture occurring as the crop approached maturity.

Improved Swedish oats, a variety for which resistance to rust is claimed, was planted on a garden plat on November 20, 1916, an application of stable manure estimated at 50 tons per acre being worked into the soil before planting. The crop made rank and vigorous growth, remained free from rust, and yielded at the rate of almost 24 tons of green feed per acre when the crop was cut on April 9. Plantings of the same variety were made on December 12 and 28 and on January 16, the first and last of these plantings being grown with sodium nitrate as the sole fertilizer, while the crop planted on December 28 was grown on soil given an application of stable manure at the rate of 56 tons per acre (see Pl. VII, fig. 1). As all these last crops were cut after a shorter period of growth than the first planting, none produced as heavy yields, but all gave ex-

cellent returns. A specially gratifying feature in the test of this variety is the fact that heavy crops were produced during the coolest season of the year when green feed is always scarce. The freedom of this crop from rust and attacks of aphids and its response to the application of commercial fertilizers, even on a soil extremely deficient in humus, are also important factors in its favor.

Spelt and spring rye drilled adjacent to and at the same time as the Improved Swedish oats planted on November 20 were badly infested with a species of aphis throughout the greater portion of the growing year, the spring rye being the more seriously damaged. The oats, notwithstanding its close proximity to the infested plats, remained free from these pests at all times. Of the same crops again planted in adjacent plats on December 28, spring rye and spelt were seriously attacked by plant lice, while the oats remained unharmed. On February 17, however, cattle invaded the experimental plats, feeding upon the bamboo grass and the plat of oats. Six days later young tender blades of oats, which had sprung to a height of 6 or 7 inches, were seen to be attacked by the aphids, indicating that new ratoon growth will perhaps always be susceptible to the ravages of this pest. The attack was not, however, made in great numbers nor was it a persistent one, the pests almost entirely disappearing after an infestation of about three weeks.

Spelt and spring rye were both planted during the year and, as has been pointed out in the preceding discussion, both were attacked by plant lice. These crops were cut after a period of growth covering 4½ months, spelt yielding at the rate of 15,687 pounds, and spring rye 17,430 pounds per acre. Neither of these crops promises to equal the Improved Swedish oats.

Thousand-headed kale and Dwarf Essex rape, drilled in rows on November 20 and transplanted to a permanent field location on January 5, both made vigorous growth during the cold season and yielded at the rate of 19.5 and 22 tons of green feed per acre, respectively. These plantings were made on thoroughly prepared soil fertilized with stable manure at the rate of 50 tons per acre before planting. Dwarf Essex rape, planted in April of the preceding fiscal year, was totally destroyed by cutworms, indicating that this crop and possibly the closely related kale are subject to serious damage from cutworms during the season when these pests are most prevalent.

Bur clover of six different species has been grown at the substation during the past fiscal year, their trial being suggested by the vigorous growth of a few volunteer plants of what was believed to be the ordinary California bur clover during the preceding fiscal year. Planting was made on well-manured and thoroughly prepared soil on November 20, 1916, seed of *Medicago scutellata*, *M. orbicularis*, *M. arabica*, *M. hispida*, *M. hispida sardoa*, *M. tuberculata*, all of which

was obtained through C. A. Sahr, assistant agronomist of the station, being planted at that time. The growth of all species was extremely slow during the first ten weeks after planting, while all made rapid growth after that time. *Medicago scutellata* was the first to reach maturity and very plainly ranked lowest among all species in the production of forage. The planting was made on a very small scale, each species occupying 92 linear feet of drilled row, and no definite comparative yields could be obtained.

### GROUND CHERRIES.

The extreme ease with which the native poha is grown throughout upper Olaa led to a test during the past fiscal year of the closely related and improved ground cherry from the United States. Seeds of two varieties, the improved ground cherry and Mammoth Purple-Fruited ground cherry, were obtained and sown in seed flats on February 2, 1917, the resulting seedlings being transplanted to the field on March 30. The improved ground cherry developed comparatively slowly and had a low, spreading habit of growth. The fruit is small, yellow, and sweet. As compared with the poha, the Improved ground cherry has, in this one test, produced a lighter yield and smaller fruit with no special improvement in flavor. The Mammoth Purple-Fruited ground cherry made a more rapid growth, the plants being comparatively large, erect, and very prolific. The crop from this planting has not yet fully matured, but fruits measuring more than $1\frac{1}{4}$ inches in diameter and very much larger than those of the ordinary poha have already been found. This variety is very promising and, due to the very large size of its fruit, is attracting much local interest. As the crop is yet immature, no comparative tests to determine the relative values of this variety and the poha as cooking fruits have been made.

### BLIGHT RESISTANT POTATOES.

The only obstacle in the way of producing large yields of potatoes in the Glenwood section appears to be the presence of the potato blight. Stories of such bountiful potato crops that prices fell to 50 cents a bag in the days prior to the introduction of this disease are frequently related by the older residents of the district, and it is an unquestioned fact that the crop develops at present with unsurpassed vigor until the blight strikes it. Heavy and frequent rains favor the disease and also tend to render ineffective the employment of fungicidal sprays as a control measure. Having these conditions to contend with, work leading toward the discovery or development of a blight-resistant variety would appear to offer greatest promise of a satisfactory solution of the problem. During

the past fiscal year five varieties of white potatoes advertised as possessing some degree of immunity to this disease were tested at Glenwood, all proving to have little or no resistant qualities. The variety Portuguese Red, having a deep red color and rather inferior quality, and known to be partially resistant to this disease, has been grown on the island of Hawaii for many years. During the past fiscal year material was obtained of two new varieties, these being secured from the originator, K. Yamato, of Honokaa, Hawaii, and grown in comparative tests with the Portuguese Red potato and five white varieties. These two varieties of what has been named the "Hamakua Hybrid" potato were exhibited at the Second Hawaii County Fair, held at Hilo September, 1916, and are here designated as Blue Ribbon and White Ribbon, from the prizes awarded them at that fair. The variety Blue Ribbon is of a light red color but quite distinct from the darker colored red Portuguese Red potato. White Ribbon is said to show some variation in color but is usually almost a pure white potato with eyes of a reddish-purple hue. Potatoes for the first comparative test were planted January 16, 1917. During the early stages of growth of this plat, several strong Kona winds so whipped and tore the plants that the presence of the blight could not be immediately detected, and comparisons could only be made of the final yields. All varieties were planted on the same date and plat, in rows of identical length, with equal distances between hills, with the same kind and quantity of fertilizer, and with the maintenance of uniformity in every controllable condition. The results of the tests, showing the relative yields of the different varieties in ounces per row, are shown in the following table:

*Yields of potatoes in test of blight-resistant varieties.*

| Variety. | Number of rows. | Total yield. | | Yield per row. |
|---|---|---|---|---|
| | | *Lbs.* | *Oz.* | *Ounces.* |
| State of Maine | 3 | 12 | 9 | 67 |
| Green Mountain | 3 | 13 | 4 | 71 |
| Vermont Gold Coin | 4 | 20 | 12 | 83 |
| Eureka Extra Early | 4 | 22 | 0 | 88 |
| Great Divide | 2 | 11 | 4 | 90 |
| Portuguese Red | 3 | 21 | 8 | 115 |
| Blue Ribbon (Hamakua Hybrid) | 3 | 25 | 7 | 136 |
| White Ribbon (Hamakua Hybrid) | 3 | 25 | 0 | 171 |

Another trial was begun on March 16, 1917, of single rows each of the varieties Vermont Gold Coin, White Ribbon, Eureka Extra Early, Blue Ribbon, State of Maine, and Portuguese Red, planted under identical conditions. These rows were arranged adjacently with the varieties in the order named above so as to alternate rows of the nonresistant potatoes with rows of the resistant varieties and thus to make the results more impressive during the test. Blight

was first observed on all white varieties on April 21, but it did not appear on the White Ribbon, Blue Ribbon, or Portuguese Red until May 8. The progress of the attack was much more rapid in the case of the white potatoes than in that of the resistant varieties. Photographic views (Pl. VII, fig. 2) taken on May 26 show all plants of the ordinary white varieties completely dead, while those of the three resistant varieties are still making vigorous growth. As the experiment was still in progress at the close of the fiscal year, comparative yields could not be reported. The study of these promising varieties will be continued during the coming year.

## REPORT OF THE AGRONOMY DIVISION.

By C. A. Sahr.

In addition to the regular work of this division a project was begun on the edible canna (*Canna edulis*), the object in view being the production throughout the islands of this most important food plant. Because of the shortage of labor, work on the fiber projects inaugurated in 1916 was dropped for an indefinite period. Active work on some of the other projects was also dropped temporarily in order that this division might concentrate its efforts on increasing local food production.

### AQUATIC CROPS.

The work with rice and taro was continued at Waiau, Oahu. In relation to the aeration of soil tests with rice it is of interest to note that the comparative differences in yields of the aerated and non-aerated plats have grown considerably less. Neither of the plats received either manure or fertilizer for some time previous to the beginning of this test, in which, in 1916, the increase favoring non-aeration was 18.7 per cent for the spring crop, 4.9 per cent for the fall crop, and 3.1 per cent for the 1917 spring crop. As in previous tests at Waiau, Oahu, the variety of rice grown is the Bezembo.

### POTATOES.

Owing to the saturated condition of the soil this year at the central station the planting of Irish potatoes was postponed until the second week in April, a much later season than usual. Inasmuch as the object of the planting is to obtain material for pathological investigations, supervision of the planting, cultivation, and spraying with fungicides of the stands obtained is almost entirely under the direction of the pathologist.

In a duplicate planting of Burbank and Early Rose potatoes at the Tantalus substation, an average yield per hill of 0.47 pound was obtained with both varieties. These very low yields are attributed to attack by mites, in addition to the effect of dry weather.

FIG. 1.—IMPROVED SWEDISH OATS AT GLENWOOD.

FIG. 2.—BLIGHT RESISTANT POTATOES. HAMAKUA HYBRIDS UNAFFECTED, OTHER VARIETIES BLIGHTED.

FIG. 1.—PERUVIAN ALFALFA, SHOWING STIMULATED GROWTH WHERE BRUSH WAS BURNED.

FIG. 2.—PREPARATION FOR HEAT TREATMENT IN SOIL EXPERIMENT.

FIG. 3.—EFFECT OF HEAT TREATMENT AND STABLE MANURE. COWPEAS IN FOREGROUND, CASSAVA IN BACKGROUND.

In order to obtain cuttings to supply the growing demand for propagating material of good types of the sweet potato, about five-eighths acre was planted to three varieties of this root crop, in the selection of which the determining factors were medium early maturity and heavy foliage, together with reported resistance to attack by the sweet potato leaf miner.

## LEGUMES.

A new variety of pigeon pea (*Cajanus indicus*) from India, seed of which was received from the Haiku substation in 1915, has been tried out with favorable results by the division. This variety is not nearly so tall and erect as are the varieties of Porto Rican introduction, but it is much more bushy in habit of growth and its leaves are from one-fourth to one-third larger than those of the West Indian type. The pods are small, averaging 2 inches for the entire length, three to five seeded, and noticeably notated (marbled), with the peas about two-thirds the size of the Porto Rican variety Chiquita.

From records of various tests of alfalfa for a period of 32 months, individual yields based upon 9 cuttings per annum are as follows: Utah Common, 30 tons green forage per acre; Kansas Common, 28.4 tons; Peruvian, 21.7 tons; and Turkestan, 14.7 tons. From the same number of cuttings per annum for a period of 28 months, the individual yields from Grimm, dryland, and common alfalfa are, respectively, 26.6, 26.4, and 9.3 tons.

Ordinarily alfalfa can be cut once a month throughout the year. However, on the sloping fields of this station, to omit cutting during excessively wet periods has been found to lessen erosion.

Tests with tepary beans for seed yields have given varying results. A fall sowing made in field B of the station grounds produced a growth of 9 inches, the plants dying before blooming, probably because of saturated soil conditions. A second sowing in Magazine field, drilled 1½ feet apart, failed to make sufficient growth to fill the space between the drills but yielded at the rate of 10 bushels of shelled beans to the acre. In the third test, planting was postponed until drier conditions prevailed. The beans, drilled in furrows 2 feet apart at the rate of 15 pounds per acre, reached maturity in 76 days from the time of sowing and yielded at the rate of 33.4 bushels of 60 pounds each per acre.

## GRASSES.

Roots of *Polytrias præmorsa* (S. P. I. No. 32111) and blue couch grass (*Digitaria didactyla*) were received October 26, 1916, and were set out in the forage crop garden the same day. The resulting plants

of *Polytrias præmorsa* came into bloom and set seed early in February, 1917, the blooming continuing from then on. The two original roots of this grass have grown into a single sod now covering about 4 square feet. The growth assumed by the blue couch grass, while considerably more spreading, has not yet made any sod nor come into bloom.

With Napier grass (*Pennisetum purpureum*) the blooming periods seem to be limited to the months of April and November. A trial cutting of this grass made late in April, after its third blooming period from the time of planting, indicated a yield of 46 tons green forage per acre. It is planned to cut this grass, which ratoons freely, after each blooming period. Although protected from birds by a large cage, the heads do not seem to produce seed of germinative ability.

Of the demonstration plats in field N planted to Wilder, fuzzy top, Australian blue, and Natal redtop grass, the last two are producing the largest yields. These last two grasses may be cut for hay or forage at intervals of 70 days, but the Wilder and fuzzy top, though furnishing considerable herbage well adapted for pasture, do not head out well excepting in March and October.

## SORGHUMS.

No new varieties of sorghums of either grain or forage types were tried during the fiscal year. Of the stand of seven varieties maintained for records of longevity and yields, the Sugar Drip sowed in April, 1915, one year previous to the sowing of the grain varieties in this test, still maintains the lead in yields of both grain and forage. Owing to the ravages of birds and the shortage of labor for the protection of the maturing crops of seed, it has been possible to mature only a single grain crop annually.

## NUT-GRASS CONTROL.

The work in nut-grass control has shown decided results from spraying with arsenate of soda. During the first year of this work the nut grass required spraying at average intervals of 40 days, or whenever it was in full bloom, and during the second year at average intervals of 65 days. In the past year the last spray was applied in October, and while new shoots have sprung up since this application, no blooms have yet appeared during this period of nine months. The spray formula used in nut-grass control is 1 pound white arsenic, one-half pound caustic soda, and 1 gallon water. The mixture should be boiled until clear and diluted with water to 20 gallons.

### CORN.

Owing to the severe attacks by the leaf hopper (*Peregrinus maidis*) the variety and fertilizer tests with corn have failed. A planting of sweet corn made in November, 1916, was found to be infested with the leaf hopper during the latter part of December. Through the cooperation of the Territorial Board of Agriculture and Forestry, a large number of corn leaf hopper parasites (*Ootetrastichus* sp.) were obtained and released at various periods during the life of the corn stand. In this manner the corn hopper was controlled sufficiently to bring the stand of sweet corn to maturity, the yield being at the rate of 43 bushels of ear corn per acre. However, owing to the start obtained by the leaf hopper in the first planting of sweet corn, a second test with Reid's Yellow Dent corn failed entirely.

### RAPE.

Seed of Dwarf Essex rape distributed to farmers for poultry pasturage have brought reports of a very satisfactory nature to the division.

### EDIBLE CANNA.

A planting of edible canna (*Canna edulis*) was made December 8, 1915, from a small quantity of tubers received from Judge J. A. Matthewman, Kailua, Hawaii. Of the resulting eight plants, one was pulled June 6, 1916, yielding 8.5 pounds roots and 8.25 pounds foliage, the remaining seven being harvested January 26, 1917, with a yield of 59 pounds mature tubers, 52.5 pounds immature tubers or suckers, and 52 pounds forage (leaves and stems), a rate of 23 tons edible tubers, 20.5 tons immature tubers, and 20.25 tons forage per acre. As the exact time that the edible canna was first introduced into this Territory is not known (though it is believed to have been about 1898), information regarding its introduction will be gladly received. In various districts of the Territory, it has been grown largely during the last few years by the native Hawaiians, forming a considerable portion of their diet. The plant sends out new shoots at various periods, the corms of which form the propagatory portions of the plant. Under Honolulu conditions, the stems attain a height of 5 to 8 feet and blossom in 4 to 6 months. The light green leaves and scarlet blooms render the plant quite valuable as an ornamental.

### CASSAVA.

Two varieties of cassava, a white sweet sort from Trinidad and the red bitter kind common in the islands, were planted in the summer of 1915. Both stands were harvested in March, 1917, the white

variety yielding at the rate of 31 tons, the red 16¼ tons fresh roots per acre.

A second planting of the same varieties was made at Magazine field in February, 1916, which should have been harvested in June, 1917, but owing to the demand for cuttings during the present food emergency, harvesting the roots has been deferred in order to save time in the production of cutting material.

## SEED DISTRIBUTION.

During the early part of the fiscal year the demand was chiefly for seeds and cuttings of pasturing and soiling crops. Seed of several tame grasses were imported from the mainland in lots of 50 pounds each for distribution among the farmers and graziers at the higher elevations, but distribution was deferred in order to meet a possible shortage of seed in the near future. Cassava cuttings, of which 37,000 were distributed between April 1 and June 30, 1917, and edible canna tubers, of which 1,600 pounds was sent out for home-garden planting, were the chief food plant distributions during the year.

## FORAGE-CROP PROBLEMS AT CASTNER, OAHU.

Preliminary work upon the forage-crop problem was begun in July, 1916, on the 13-acre tract set aside for experimental planting on the military reservation at Castner, Oahu. A rain gauge was installed June 30, 1916, and a careful precipitation record has been kept.

Analyses made by the station chemist for the manganese content of six samples of surface soil (first foot) and subsoil (second foot) showed from 1.24 to 6.02 per cent manganese dioxid in the surface soil and from 0.7 to 3.67 per cent in the subsoil.

From preliminary plantings of Sudan grass and common alfalfa made by Capt. John S. Fair, of the Quartermaster Corps of the Army, in February, 1916, it was observed that in four months these crops had only 40 per cent stands in normal soil, even though the rainfall had been unusually good. The entire tract was divided into 9 sections, each 115 feet wide. As a dividing line between each section and also to serve as a windbreak, 2 rows of pigeon peas 5 feet apart were sown at distances of 110 feet, bringing the dividing line between the sections midway between the pigeon-pea rows.

The planting of forage crops began July 21, 1916, in section VII, which was sown entirely to grain and sweet sorghums. Section VI was planted to an African nonsaccharin sorghum (Adyiba) and Sudan and Tunis grass. Section V was planted August 4, 1916, to Japanese, pearl, and Chinese millets, teosinte, and Japanese cane.

In every case rain followed these planting days in sufficient quantity to bring up the seeds. It was observed, however, in the course of a week that the stands had become so depleted by birds (plover and skylarks), which fed upon the young green shoots, that it was necessary to replant all of the sections, excepting the Japanese cane, on August 15, 1916. Good stands of all but teosinte were obtained and maintained, but due to the effect of the manganese soil all crops, with the exception of the pigeon peas and Japanese cane, succumbed entirely, following a period of about 70 days' stunted growth.

Planting operations were resumed in section VII late in October, following very good rains. Peruvian alfalfa was sown in two plats of five drills each, the drills being spaced 1½ feet in the first plat and 2 feet in the second. Pearl millet was sown in two plats of five drills each at distances between drills of 2 feet and 3 feet, respectively. Single plats of five rows each, spaced 2 feet apart, were sown to Japanese and Chinese millet, the rest of section VII being sown to sunn hemp. Very good stands were obtained in this planting. While moist conditions prevailed until the end of May, 1917, the various stands, although keeping alive, made no better growth than the summer planting had made, except on small areas of 2 or 4 square yards in extent scattered throughout the section. Investigation showed that piles of brush had been burned on these small areas, as evidenced by bits of charred stems through the soil. Only the sunn hemp made perceptible growth throughout the wet season. The millet died out when the dry season set in late in May. During the last week of May the alfalfa plats came into bloom at a height of 13 inches, and were cut June 2. The growth put forth by the alfalfa stands since this cutting (30 days), aided by a rainfall of 1.15 inches for that period, indicates that the next cutting may yield possibly 40 per cent of normal.

Due to the observed stimulating effect upon the growth of plants occupying small areas where brush heaps had been burned (see Pl. VIII, fig. 1), it was thought promising to test the effect of brush burning on a large scale in conjunction with a heavy application of barnyard manure. A strip of land in section VIII, 560 feet long and 50 feet wide, was lined off after plowing into four divisions each 12 feet wide and each treated for its entire length as follows: Division A, check, no treatment; division B, soil ditched 1 foot deep and piled with brush for burning (see Pl. VIII, fig. 2); division C, soil leveled, piled with brush for burning; division D, soil ditched 1 foot deep, given stable manure at the rate of 33 tons per acre and rolled level. Divisions B and C were burned off following the completion of the brush piling. The ashes on the surface of division C were swept into the furrow or dividing line between divisions C and

B, the object being to determine whether the results were due to heat or to the manurial effect of the ashes or to both. Divisions B, C, and D were then thoroughly cultivated with a five-shovel horse hoe and lined off for planting in furrows 18 inches apart. Each division was then marked out in plats 12 feet in length. The crops, of which there are 45, were planted in plats side by side, so as to be represented in each division. With the exception of the root crops, sorghum, cowpeas, and pigeon peas, which were planted in furrows 3 feet apart, all the plats were sown in 18-inch rows. All planting was done during the second and third week of March, 1917.

The resulting growth of the crops (see Pl. VIII, fig. 3) in response to the different treatments, made on a basis of 100 per cent for normal growth under normal soil and moisture conditions, for all the full stands are given in the accompanying table:

*Effect of heat treatment and stable manure on manganese soil.*

[Based on 100 per cent for normal growth.]

| Crop. | Division A, no treatment. | Division B, ditched soil heated. | Division C, level soil burned over. | Division D, stable manure, 33 tons per acre. |
|---|---|---|---|---|
| Grasses: | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Rhodes | 15 | 80 | 20 | 100 |
| Tall meadow oat | 5 | 10 | 10 | 30 |
| *Bromus inermis* | 5 | 10 | 10 | 15 |
| Teff | 10 | 50 | 45 | 100 |
| Bermuda | 5 | 35 | 60 | 100 |
| Giant Bermuda | 10 | 30 | 20 | 60 |
| Mitchell | 5 | 15 | 5 | 100 |
| Sudan | 10 | 40 | 60 | 100 |
| Australian water | 0 | 5 | 5 | 30 |
| Fuzzy top | 5 | 10 | 10 | 20 |
| Wilder | 5 | 10 | 10 | 20 |
| Tunis | 5 | 25 | 15 | 100 |
| Oats: | | | | |
| Sixty-Day | 20 | 60 | 55 | 50 |
| Fulghum | 25 | 70 | 40 | 80 |
| Red Rustproof | 20 | 40 | 35 | 60 |
| Swedish Select | 10 | 50 | 30 | 70 |
| Victory | 10 | 65 | 60 | 70 |
| Swedish Victory | 10 | 65 | 60 | 70 |
| Swedish Crown | 20 | 55 | 65 | 70 |
| Wheat: | | | | |
| Galgalos | 30 | 55 | 55 | 60 |
| Palouse Bluestem | 10 | 45 | 55 | 80 |
| Little Club | 10 | 45 | 55 | 70 |
| Japanese millet | 30 | 30 | 30 | 40 |
| Edible canna | 20 | 30 | 40 | 50 |
| Sorghum: | | | | |
| Adyiba | 5 | 15 | 20 | 90 |
| Sugar Drip | 30 | 20 | 40 | 100 |
| Cassava: | | | | |
| Bitter | 40 | 55 | 60 | 100 |
| Sweet | 50 | 60 | 60 | 100 |
| Legumes: | | | | |
| Peruvian alfalfa | 10 | 55 | 50 | 70 |
| White sweet clover | 5 | 40 | 30 | 60 |
| Iron cowpeas | 20 | 75 | 90 | 100 |
| Kulthi | 10 | 20 | 20 | 30 |
| Mutn bean | 65 | 75 | 70 | 90 |
| Tepary bean | 60 | 75 | 85 | 95 |
| Pigeon pea | 60 | 85 | 90 | 100 |

Other important work on the production of forage crops on manganese soils includes a study of the effect of spraying the various crops with iron compounds. Portions of the stands of jack beans, pigeon peas, velvet beans, alfalfa, millet, Japanese cane, and grasses were sprayed every two weeks during April and May with a $2\frac{1}{2}$ per cent solution of copperas, because of the burning effect of which strength the spray for succeeding applications was diluted to $1\frac{1}{4}$ per cent. Effects of the spray were slightly noticeable on the alfalfa previous to the cutting made June 2, but not on later growth. With the Japanese cane, however, the effects were clearly discernible.

## REPORT OF THE TERRITORIAL MARKETING DIVISION.

By A. T. Longley.

The volume of business transacted by the division during the year was greater than for any previous year in its history. Sixty kinds of island products were marketed for 474 different consignors. The individual consignments, numbering 2,538, which included nearly every island agricultural product from green vegetables and preserved fruit to dressed meat and live stock, and ranged in value from a few cents to more than a thousand dollars, were sold for a total of $121,512.90. In addition to the consignment sales, seeds, crates, and merchandise valued at $18,006.15 were sold to producers and others. The number of individual consignors from the different islands were as follows: Oahu, 321; Hawaii, 73; Maui, 45; Molokai, 24; Kauai, 11. While Oahu led in the number of consignors and consignments, Maui's shipments, which were made up largely of beef, hogs, corn, beans, and potatoes, were of much greater value.

The retail meat and vegetable branches were established to furnish an outlet for the consigned produce which could not be sold to advantage to the local retail stores. It was the intention to run these on a basis which would be just self-supporting, and although they did not quite pay for the cost of operation, they served a most useful purpose in that they greatly increased the returns of the consignment branch. Until these retail departments were established the division experienced great difficulty at times in disposing of consigned produce to local dealers and often large quantities of perishable fruits and vegetables were lost. With the establishment of the retail branches it became possible to dispose of all such produce directly to the consumer in case the local stores were not in the market at that time. One reason for the difficulty experienced in selling locally grown consignments of vegetables to the retail stores is that most of them have regular standing orders for such produce to be shipped each week from the coast, the island-grown supply hav-

ing been irregular in coming into the market and frequently not put up in the packages desired by the trade.

The recent session of the legislature increased the appropriation for operating expenses for the ensuing biennium from $24,000 to $30,000. In addition to this, the sum of $5,000 was appropriated for extension work among the producers, advising them as to what and when to plant and how best to prepare and grade for shipment to market. The producer often does not understand what the consumer demands, and without definite instruction along these lines he is not in a position to compete with the mainland concerns which have long since realized the economic necessity of standardizing their products. A special revolving fund of $2,500 was provided to permit the purchase of vegetable and other food-crop seed for sale at cost plus actual selling expenses. The revolving fund of $7,500 provided by the legislature in 1915 was increased to $15,000 and made more readily available for paying consignors. Of the original $7,500 there is on deposit with the Territorial treasurer the sum of $2,638.19, while $2,894.69 is represented by an inventory of pineapple crates on hand and $1,967.12 by accounts receivable.

An act was passed at the last session of the legislature defining the powers and duties of the division and placing it under the supervision of the Board of Commissioners of Agriculture and Forestry of the Territory, beginning July 1, 1917.